TB Wood's

BERGES

Operating Instructions

E-TRAC®

EF1 Microdrive

Part No. 38005221

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1 Introduction and Safety Tips

1.1 General Information

Please read these instructions carefully and take all tips and suggestions they contain into account before installation and commissioning of the converter.

These instructions must be made available to all users. The user must be familiar with the unit before any work is performed. This especially includes the safety tips and warnings.

Symbols Used

⚠ DANGER! This symbol is used when the life or health of the user is endangered or considerable property damage may result.

⚠ CAUTION! This symbol is found in the operating instructions in places where important points for the safe and correct operation of this converter are found.

1.2 Safety Tips

All tips found in this chapter must be complied with in order to ensure the safety of users and machines or equipment.

1.2.1 General Safety Tips

⚠ DANGER! Converters are operated at voltages which may cause shocks which endanger life if touched. They may contain exposed, high voltage or high temperature surfaces while in operation in accordance with their safety type. Serious danger to persons or property may result from unauthorized removal of the necessary covers, improper use, incorrect installation or operation.

⚠ DANGER! All work for the transport, installation, commissioning, and start-up, as well as for maintenance, is to be carried out by qualified personnel (IEC 364 or CENELEC HD 384 and national accident prevention measures must be complied with). Qualified personnel as defined by these instructions are personnel who are familiar with the set-up, assembly, commissioning, and operation of the product and have suitable qualifications for such work.

1.2.2 Proper Usage

⚠ DANGER! The use of the converter explained in these instructions is solely for the control of the speed of three-phase AC motors.

Converters are components which are intended to be installed in electrical equipment or machines.

Commissioning of the converter is prohibited until it has been ensured that the system or machine fulfils the provisions of the EU Guidelines 89/392/EWG (Machine Guideline) and 89/336/EWG (EMC Guideline).

The converter fulfils the requirements of the Low Voltage Guideline 73/231/EWG. The harmonized standards of the series EN 50178 are applied.

⚠ CAUTION! Those responsible for setting up or operating the system are liable for damage resulting from improper use of the converter.

1.2.3 Transport, Storage, Installation

⚠ CAUTION!

The converter must be protected from improper stress. No structural elements may be bent and/or isolation distances may be changed for transport and handling. The units contain structural elements that are endangered by electrostatic discharges which may be damaged or destroyed as a result of improper handling. Touching structural electronic elements and contacts should be avoided. Units that display defects to electrical or electronic components may not be put into operation since maintenance of the applicable standards can no longer be ensured. The minimum distances and adequate cooling must be ensured during installation. The climatic conditions in accordance with EN 50178 are to be maintained.

1.2.4 Electrical Connections

⚠ DANGER!

The unit is to be separated from the power supply and suitably secured before any installation and connection work.

⚠ DANGER!

After the converter has been safety isolated, you must wait **at least 5 minutes** until the intermediate circuit condensers have discharged. Only then may work be begun on the unit. The discharge period may be exceeded **considerably** in the case of faults.

⚠ CAUTION!

The converter is planned for use with a fixed connection since leakage currents >3.5 mA may occur due to the built in EMC filter. See also EN 50178 for dimensioning and placement of the protective conductor.

⚠ DANGER!

The converter is designed for installation in a switchgear cabinet and may only be operated after it has been grounded.

⚠ CAUTION!

The installation regulations and the information in these operating instructions must be complied with for proper operation of the converter.

⚠ DANGER!

When using a residual-current-operated protective device (r.c.c.b.), the compatibility to the converter must be checked in advance. Depending on the type of unit, the following applies:

- 1 phase units: pulse current sensitive r.c.c.b. (Type A) or universal current sensitive r.c.c.b. (Type B) are permitted.
- 3 phase units: Only universal current sensitive r.c.c.b. (Type B) are permitted.

Otherwise another protective measure like separation from the environment using double or reinforced insulation, separation from the power supply, or similar is to be employed (EN 50178). The tripping current for the r.c.c.b. must be adequately dimensioned since the capacitive current (cable shields, filters) can easily lead to spurious tripping.

1.2.5 Operating Instructions

⚠ DANGER!

The converter can be configured so that it automatically restarts after a fault. The system may have to be equipped with additional monitoring or protective equipment to avoid the dangers which result from this (see accident prevention regulations, etc.).

The motor can be stopped by switching off the enabling or the target value. If accidental start-up is to be prevented for reasons of safety, then the converter is to be isolated in addition, i.e. separated from the power supply.

1.3 Product Overview

Although the E-trAC® EF1 Microdrive is small in size, it is big on performance. It is an economical yet powerful solution for many industrial applications. It features remote communications capability (using Modbus® protocol), a keypad for easy configuration, and a standard NEMA 1/IP31 enclosure that removes the need for mounting in a separate enclosure.

The EF1 product family includes a wide variety of models to suit almost any input voltage requirement. See Section 2.1 on page 6 for information about the model number for a particular model).

1.4 Manual Overview

This manual contains specifications, receiving and installation instructions, configuration, description of operation, and troubleshooting procedures for EF1 Microdrive devices.

⚠ CAUTION!

We expressly state that we are not liable for damages and interruptions in operation resulting from non-compliance with these operating instructions.

We reserve the right to make changes to improve the unit and its functions.

Before you read on, please check whether technical changes are attached in the annex to this operating manual!

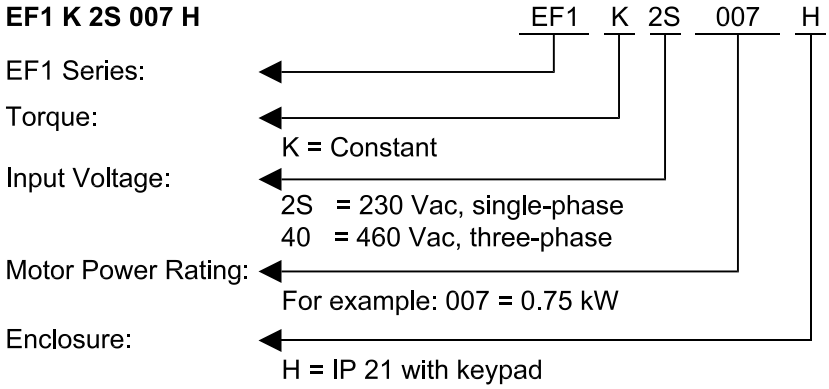
1.4.1 Publication History

Date	Version	Nature of Change
10.06.2003	02_GB	Software revision RVLVL = 036 and RVLVL2 = 104.

2 Technical Characteristics

2.1 Interpreting Model Numbers

The model number of the EF1 Microdrive appears on the shipping carton label and on the technical data label affixed to the model. The information provided by the model number is shown below:



2.2 Power and Current Ratings

Model Number EF1K-	Motor Power	Input		Output	
	kW	Voltage (Vac)	Current [1] (A)	Voltage (Vac)	Current (A)
2S003	0.37	200...230 ±15% Single-phase	4.9	0...230 Three-phase	2.2
2S007	0.75		8.0		3.6
2S015	1.5		14.6		6.8
2S022	2.2		20.7		9.6
40007	0.75	380...460 ±15% Three-phase	3.0	0...460 Three-phase	2.1
40015	1.5		5.2		3.8
40022	2.2		7.2		5.7
40030	3.0		8.7		6.7
40040	4.0		12.0		8.9

[1] Input current listed is at maximum output loading and minimum input voltage.

2.3 Environmental Specifications

Operating temperature	0 °C...+40 °C
Storage temperature	–20 °C...+65 °C
Maximum heatsink temperature	100 °C
Humidity	0% to 95% non-condensing
Altitude	1000 m without derating
Maximum vibration	5.9 m/s^2 [0.6 G]
Acoustic noise	80 dba sound power at 1 m
Cooling	Natural convection (0.37 and 0.75 kW models). Fan cooling (1.5 kW and larger models)

2.4 Electrical Specifications

	230 Vac Models	460 Vac Models
Voltage input	200...230 Vac ±15%	380...460 Vac ±15%
Line frequency	50...60 Hz ±2 Hz	
DC bus voltage for: Overvoltage trip Dynamic Brake activation Nominal undervoltage (UV) trip	 407 Vdc 391 Vdc 202 Vdc	 805 Vdc 780 Vdc 510 Vdc
Control system	Voltage Vector pulse width modulation (PWM). Carrier frequency = 4, 6, 8, 12, and 16 kHz	
Output voltage	0 to 100% of line voltage, Three-phase	
Overload capacity	150% of rated rms for 60 seconds	
Rated output frequency	50/60 Hz ±5%	
Frequency range	0...1000 Hz	
Frequency stability	±0.02 Hz from 0 to 300 Hz (digital) ±0.01 Hz from 300 to 1000 Hz (digital) 0.1% (analog) over 24 hours ±10 °C change	
Frequency setting	By keypad or by external signal (0 to 5 Vdc, 0 to 10 Vdc, 0 to 20 mA, or 4 to 20 mA)	
Emitted interference/ immunity to interference	Limit values maintained with filter installed. Three phase units: Requirements according to EN61800-3:1996 and A11:2000 for use in industrial environments. Single phase units: Requirements according to EN61800-3:1996 and A11:2000 for use in residential environments.	
Agency listings	UL and cUL Listed, CE Mark	

2.5 Control Features Specifications

A1 reference input	0...5 Vdc, 0...10 Vdc, 0...20 mA, 4...20 mA (10 kΩ/50 Ω)
A2 reference input	0...10 Vdc (20 kΩ)
Reference voltage	10 Vdc (10 mA maximum)
Digital inputs	Off = 0 to 3 Vdc, On = 10 to 40 Vdc (for the default Active High mode of operation)
Preset frequencies	3 inputs for seven preset frequencies (selectable)
Control output	2 relay outputs – 130 Vac, 1 A / 250 Vac, 0.5 A
Analog output	2 outputs: 0 to 10 Vdc or 0/4 to 20 mA (500 Ω max.), software-adjustable programmable function
DC injection braking	Off or on with adjustable voltage (0 to 15%); adjustable time (0.1 to 20.0 s) or continuous; activation by terminal strip or frequency
Torque limit	Programmable limit (in percent of the nominal torque of the motor)
Speed ramps	0.1 to 600.0 s (both primary and alternate ramps)

Voltage boost	Adjustable 0 to 25% or auto-boost
Voltage characteristic	Linear or Quadratic
Timed overload	Programmable 0...100% of the nominal motor current
Non-defeatable protective features	Overcurrent, overvoltage, overtemperature, ground fault, short circuit
Slip compensation	To achieve the speed set at maximum load

2.6 Dimensions and Weights

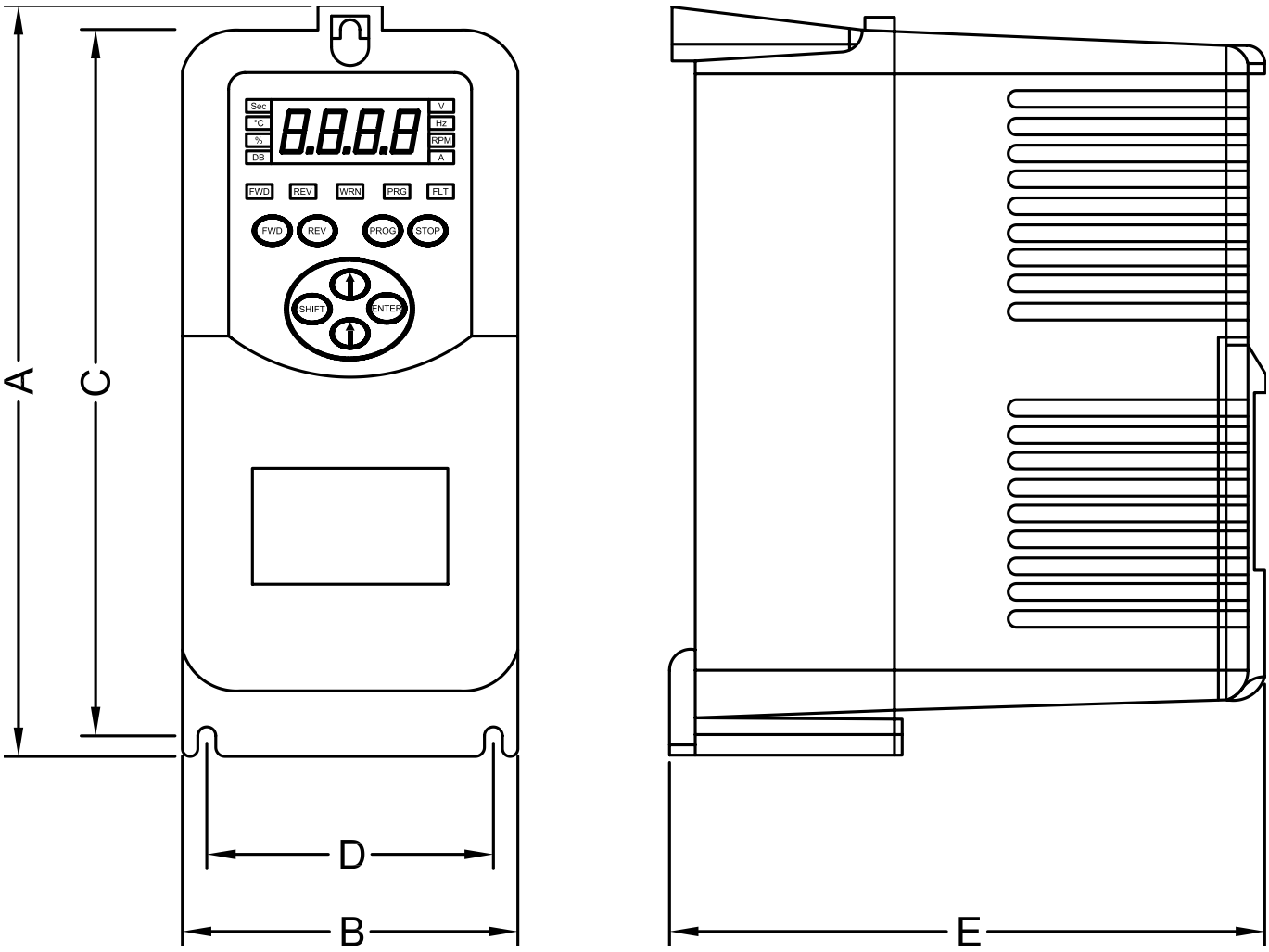


Figure 1
EF1 Microdrive 0.37 kW...0.75 kW – 1 × 230 V

Model	Power	Weight	A	B	C	D	E
EF1K2S003	0.37 kW – 230 V	1.5	178.0	87.0	168.0	75.0	155.0
EF1K2S007	0.75 kW – 230 V	1.5	178.0	87.0	168.0	75.0	155.0

NOTE:

Dimensions in mm. Weight in kg.

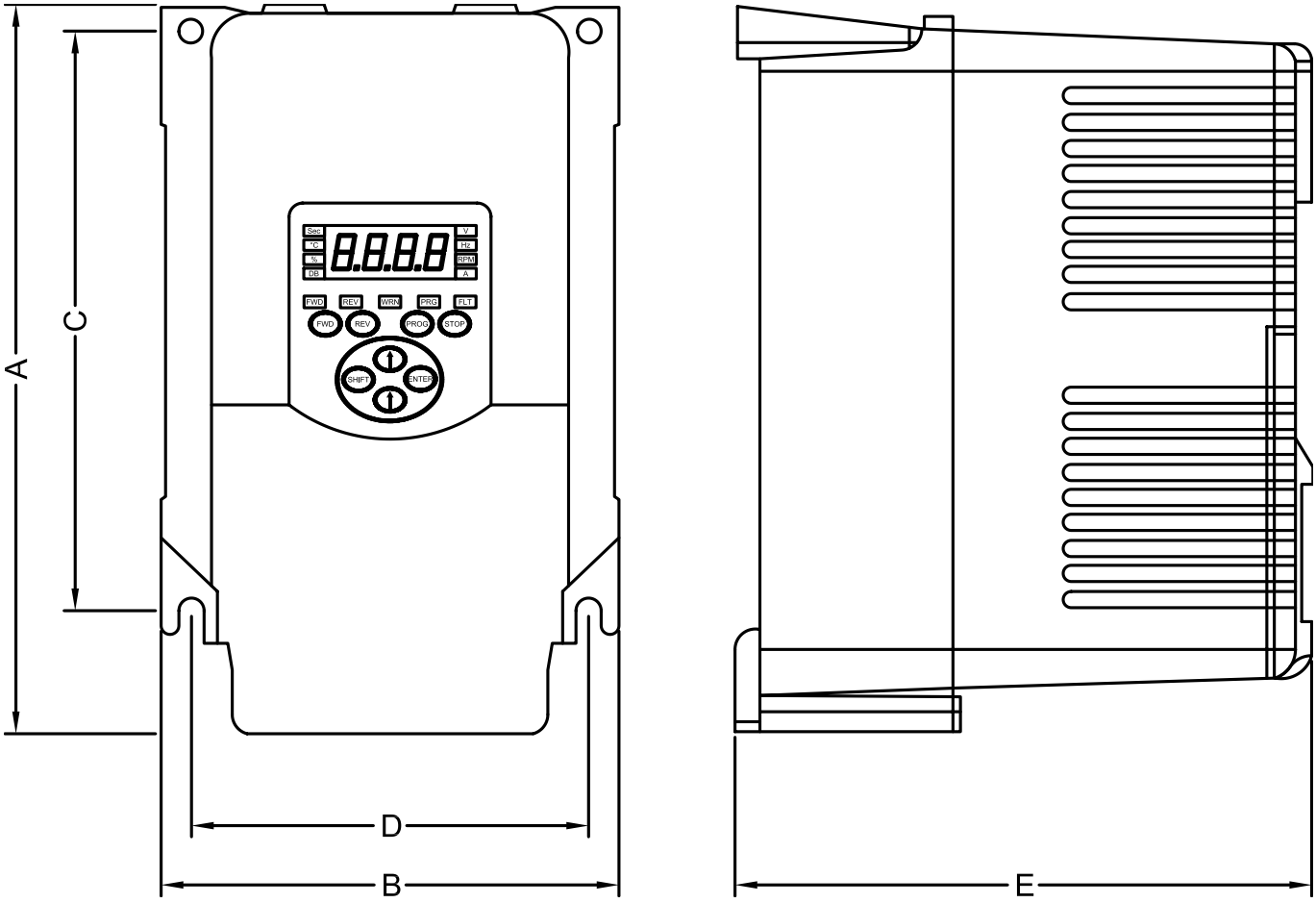


Figure 2
EF1 Microdrive 1.5 kW...2.2 kW – 1 × 230 V
EF1 Microdrive 0.75 kW...4.0 kW – 3 × 460 V

Model	Power	Weight	A	B	C	D	E
EF1K2S015	1.5 kW – 230 V	2.5	183.0	142.0	137.2	128.8	173.0
EF1K2S022	2.2 kW – 230 V	3.5	226.0	142.5	188.0	128.8	193.0
EF1K40007	0.75 kW – 460 V	2.0	177.0	105.2	137.2	94.0	173.0
EF1K40015	1.5 kW – 460 V	2.5	183.0	142.0	137.2	128.8	173.0
EF1K40022	2.2 kW – 460 V	3.5	226.0	142.5	188.0	128.8	193.0
EF1K40030	3.0 kW – 460 V	3.5	226.0	142.0	188.0	128.8	193.0
EF1K40040	4.0 kW – 460 V	3.5	226.0	142.5	188.0	128.8	193.0

NOTE:

Dimensions in mm. Weight in kg.

3 Receiving and Installation

3.1 Preliminary Inspection

Before storing or installing the EF1 Microdrive, thoroughly inspect the device for possible shipping damage. Upon receipt:

1. Remove the drive from its package and inspect exterior for shipping damage. If damage is apparent, notify the shipping agent and your sales representative.
2. Read the technical data label affixed to the drive and ensure that the correct horsepower and input voltage for the application has been purchased.
3. If you will store the drive after receipt, place it in its original packaging and store in a clean, dry place free from direct sunlight or corrosive fumes, where the ambient temperature is not less than –20 °C (–4 °F) or greater than +65 °C (+149 °F).

⚠ CAUTION!

EQUIPMENT DAMAGE HAZARD. Do not operate or install any drive that appears damaged. **Failure to follow this instruction can result in injury or equipment damage.**

3.2 Installation Precautions

Improper installation of the EF1 Microdrive will greatly reduce its life. Be sure to observe the following precautions when selecting a mounting location:

- Do not install the drive in a place subjected to high temperature, high humidity, excessive vibration, corrosive gases or liquids, or airborne dust or metallic particles. See Section 2.3 on page 6 for temperature, humidity, and maximum vibration limits.
- Do not mount the drive near heat-radiating elements or in direct sunlight.
- Mount the drive vertically and do not restrict the air flow to the heat sink fins.
- The drive generates heat. Allow sufficient space around the unit for heat dissipation.

Failure to observe these precautions may void the warranty!

3.3 Interference Suppression Measures

3.3.1 General

Frequency converters are electronic devices for use in industrial and commercial equipment. These devices cannot be operated independently according to the EMC Guideline 89/336/EWG, are only intended for further installation by competent equipment and machine producers, and therefore do not need to be labelled. The proof of conformity of the machine/equipment with the EMC Guideline must be provided by the builder or operator of the equipment.

Converters of the EF1 Microdrive series are equipped with an internal filter. They fulfil the requirements of the EMC Product Standard EN61800-3 for generally available products and are suitable for use in first environments (residential areas).

The evaluation of the conformity took place in a realistic environment under consideration of the following installation tips.

Other loads connected to the line can cause voltage spikes which can impair the function of the inverter and can even damage it. Chokes can be additionally used on the line side to protect the inverter against voltage spikes (resulting from the switching of large loads on the line).

3.3.2 Installation Tips

Electrical/electronic equipment may be influenced or disturbed in its operation via connecting leads or other metallic connections.

The electromagnetic compatibility of the system is greatly influenced by the type and style of the installation. Measures for grounding, screening, and filtering must be given special attention. Compliance with the following installation tips ensures compliance with the valid EMC limit values for the machine/equipment.

- Converter and optional components such as power line or input reactors are to be provided with large contact surfaces to the grounded installation base plate. Use of galvanised installation base plates is preferred. If painted base plates are used, then the installation surface must be free of paint.
- Power cable, motor line, and control lines are to be laid at great distances from one another.
- The motor line is to be shielded and grounded at both ends.
- Connect the shield on the motor line in the terminal box of the motor with PE. Use of a metallic cable gland may be necessary.
- An optional power line reactor is to be installed right next to the converter and connected to the converter with a shielded cable. Ground the cable shield on both sides.
- Control lines are to be shielded. Ground the shield on both sides.
- Twist unshielded control lines.
- Place cable shields with ground clamps on a large surface area of the bare metallic installation base plate or compensation rails (see Illustration 3).
- Use a central grounding point for the entire machine/system (installation base plate). Ground this point using ground lines with large cross sections or grounding bands.
- Cable shields are not to be extended using a single wire and should not be interrupted.
- Isolate the power section and the control section when setting up the switchgear cabinet or system. Shielding between the two parts may be necessary.
- Inductive contact elements (spools of protective devices or relays) are to be equipped with interference units (RC elements, free-wheeling diodes, varistors).

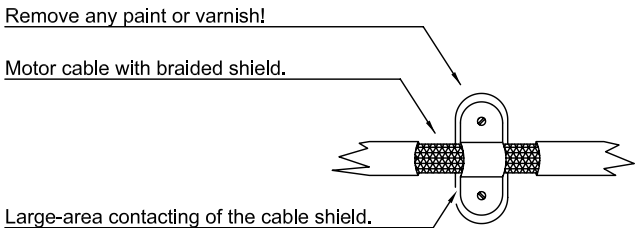


Figure 3
Grounding cable shields

4 Connections

⚠ DANGER!

HAZARDOUS VOLTAGE!

- Read and understand this manual in its entirety before installing or operating the EF1 Microdrive. Installation, adjustment, repair, and maintenance of these drives must be performed by qualified personnel.
- Disconnect all power before servicing the drive. **WAIT 5 MINUTES** until the DC bus capacitors discharge. Then measure the DC bus capacitor charge between the B+ and B– terminals to verify that the DC voltage is less than 45 Vdc.
- **DO NOT** short across DC bus capacitors or touch unshielded components or terminal strip screw connections with voltage present.
- Install all covers and close door before applying power or starting and stopping the drive.
- The user is responsible for conforming to all applicable code requirements with respect to grounding all equipment.
- Many parts in this drive, including printed circuit boards, operate at line voltage. **DO NOT TOUCH.** Use only electrically-insulated tools.

Before servicing the drive:

- Disconnect all power.
- Place a “DO NOT TURN ON” label on the drive disconnect.
- Lock the disconnect in the open position.

Failure to observe these precautions will cause shock or burn, resulting in severe personal injury or death.

4.1 Introduction

This chapter provides information on connecting power and control wiring to the EF1 Microdrive.

4.2 General Wiring Information

⚠ CAUTION!

Never connect input AC power to the motor output terminals T1/U, T2/V, or T3/W – or damage to the drive will result.

4.2.1 Power Wiring

Wire cross section and the associated protection for the power line inlet L1/R, L2/S, L3/T and motor output T1/U, T2/V, T3/W are to be selected in accordance with the information in Chapter 4.4.2. National and regional regulations must be complied with (VDE/CEI/EVU).

4.2.2 Control Wiring

Control inputs and outputs have double power line isolation and may be touched with no additional safety measures.

4.3 Input Line Requirements

4.3.1 Line Voltage

See the Power and Current Ratings table on page 6 for the allowable fluctuation of AC line voltage for your particular EF1 model. A supply voltage above or below the limits given in the table will cause the drive to trip with either an overvoltage or undervoltage fault.

Exercise caution when applying the EF1 Microdrive on low-line conditions.

For example, an EF1 2S... series inverter will operate properly on a 208 Vac line – but the maximum output voltage will be limited to 208 Vac. Now if a motor rated for 230 Vac line voltage is controlled by this drive, higher motor currents and increased heating will result.

Therefore, ensure that the voltage rating of the motor matches the applied line voltage.

4.3.2 Phase Imbalance

Phase voltage imbalance of the input AC source can cause unbalanced currents and excessive heat in the drive's input rectifier diodes and DC bus capacitors. Phase imbalance can also damage motors running directly across the line.

4.3.3 Single-phase Operation

EF1 Microdrive converter of the series 2S... (230 V units) are operated using single phase power. The connection is done using terminals L1 and N. The terminal between L1 and N is not used.

⚠ CAUTION!

EQUIPMENT DAMAGE HAZARD! Never use power-factor correction capacitors on motor terminals T1/U, T2/V, or T3/W of the EF1 Microdrive. Doing so will damage the semiconductors. **Failure to follow this instruction can result in injury or equipment damage.**

4.4 Power Terminals

4.4.1 Description of the Terminals

Figure 4 shows the power terminals for the EF1 Microdrive. Note that earth ground is not on this terminal strip; it is located separately (⏚). The following table describes the terminals.

Terminal	Description
L1/R L2/S L3/T **or** L1 N	These terminals are the line connections for input power. Single phase models connect to L1 and N. The terminal between L1 and N is not used.
B– B+	These terminals provide a connection to the DC Bus. They may be used for common DC Bus connections or for powering the drive from a DC source. Alternately, by connecting a dynamic brake unit to these terminals, braking capacity may be enhanced. See page 15 for more information.
DB B+	These terminals are the connection point for the internal dynamic brake resistor. If an external resistor is used for dynamic braking, the internal resistor must be disconnected; see page 15 for more information.

Terminal	Description
T1/U T2/V T3/W	These terminals are for motor connections.
⏚ (PE)	The models 2S003 and 2S007 have a terminal for the grounding (PE). The grounding on all other units is done using the heat sink (screw connection ⏚).

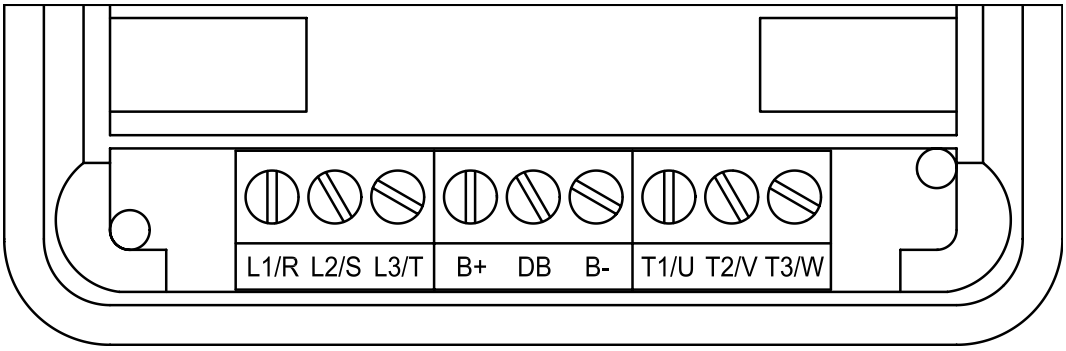


Figure 4
Power Terminals

4.4.2 Typical Power Connections

Figure 4 on page 14 shows the terminals for line power and motor output. See section 4.3 starting on page 13 for input line requirements.

Note that when testing for a ground fault, do not short any motor lead (T1/U, T2/V, or T3/W) back to an input phase (L1/R, L2/S, or L3/T).

It is necessary to provide fuses and a disconnect switch for the input AC line in accordance with all applicable electrical codes. The EF1 Microdrive is able to withstand a 150% overload for 60 s.

In order to ensure maximum possible protection for the converter, fusible links should be used to protect from over-voltage. These fuses should have a switching capacity of 200,000 A_{eff}. The following tables show the recommended ampere values for all EF1 Microdrive converters.

For 400 V line supplies we recommend time-lag type NEOZED-fuses.

EF1 Microdrive 1 × 230 V				
Model Number	**2S003**	**2S007**	**2S015**	**2S022**
Inverter power (kW)	0.37	0.75	1.5	2.2
Rated current, fuse (A)	4.0	6.0	10.0	16.0
Cable cross section, mains lead (mm^2)	1.5	1.5	1.5	2.5
Cable cross section, motor line (mm^2)	1.5	1.5	1.5	2.5

EF1 Microdrive 3 × 460 V					
Model Number	**40007**	**40015**	**40022**	**40030**	**40040**
Inverter power (kW)	0.75	1.5	2.2	3.0	4.0
Rated current, fuse (A)	2.0	4.0	6.0	6.0	10.0
Cable cross section, mains lead (mm^2)	1.5	1.5	1.5	2.5	2.5
Cable cross section, motor line (mm^2)	1.5	1.5	1.5	2.5	2.5

The medium time-delay fuses of type “Bussmann FRS-R”, for example, are recommended in networks with nominal voltages greater than 415 V. The typical operating times are 150 to 250 s for 2× overcurrent and 180 to 1500 ms in the case of 10× overcurrent.

4.5 Dynamic Braking

The EF1 Microdrive is supplied with an integrated dynamic braking (DB) resistor, and is designed to have adequate dynamic braking for most applications. In cases where short stopping times or high inertia loads require additional braking capacity, install an external resistor.

To install an external resistor, first disconnect the internal DB resistor and properly terminate the wires leading to it. Then connect the external resistor to the B+ and DB terminals. See Figure 7 on page 18 for further information.

You must also set parameter **412-DBCFG** to data value 2 and store the computed value of the DB duty cycle in parameter **413-EDBDC**. Use the following equation to compute the duty cycle for the DB resistor:

$$\text{Duty Cycle} = \frac{\text{DB Operating Time}}{\text{Full Cycle Time}} \times 100\%$$

Either minutes or seconds can be used as the unit for time variables. Make sure that both are not used in the same equation.

You should also verify with the manufacturer of the selected resistor that the resistor is indeed appropriate for your application. Contact BERGES for further assistance with other possible sizing limitations.

4.6 Control Terminals

4.6.1 Description of the Control Terminals

Figure 5 shows the control terminals found on the I/O board of the EF1 Microdrive. See page 7 for specification information concerning these features. The following table describes the control terminals.

Klemmen	Description
AQ1	Analog output 1, which is a dedicated voltage output. The default signal range is from 0 to 10 Vdc (5 mA maximum). It is proportional to the variable configured by parameter **701-METER** (see page 40). It may be calibrated while the drive is running via parameters **702-M1OFF** and **703-M1SPN** (see page 40).
AQ2	Analog output 2, which is a dedicated current output. The default signal ranges from 0 to 20 mAdc (50 to 500 Ω). It is proportional to the variable configured by parameter **709-MET2** (see page 40).It may be calibrated while the drive is running via parameters **710-M2OFF** and **711-M2SPN** (see page 40).
A1	Analog Input 1, which is used to provide speed references. The default input signal is 0 to 10 Vdc or 4 to 20 mAdc (the type of input signal is selected with parameter **205-A1TYP**; see page 28). Parameters **206-A1OFF** and **207-A1SPN** may be used to offset the starting value of the range and the size of the range, respectively; see page 29 for more information. If a 0 to 20 mAdc input signal is configured, the burden is 50 Ω. If a 0 to 10 Vdc input signal is configured, the input impedance is 10 kΩ. A potentiometer with a minimum value of 1 kΩ may be used for this input.
REF	This terminal is a +10 Vdc source for customer-supplied potentiometers. The maximum load on this supply cannot exceed 10 mAdc.
A2	Analog Input 2, which acts as a dedicated voltage input. The range of the input signal is 0...10 Vdc and may be adjusted using the parameters **208-A2OFF** (offset) and **209-A2SPN** (scaling) (see page 29). The input impedance for this terminal is 20 kΩ. A potentiometer with a minimum value of 1 kΩ may be used for this input.
CM	The common signal for both analog and digital inputs. Note that while there are two CM (common) terminals, they both connect to the same electrical point.
+V	A source for positive nominal 24 Vdc voltage, and is only intended for use with digital inputs.
D1	Digital input. This must be a Start or Run input when in terminal strip mode. See parameter **201-MODE** on page 27 for more information.
D2...D6	Digital inputs 2...6. The function of a digital input is configured by the parameter with the same name as the digital input (for example, D2 is configured by parameter **902-D2**); see page 44 for more information.
NO2 RCM2	The second auxiliary relay. The function of the relay is set by parameter **705-R2** (see page 41); the default setting is for the relay to activate when a fault occurs. Terminal NO2 is the normally-open contact; it will close when the relay is activated. RCM2 is the common terminal.
NC1 NO1 RCM1	The first auxiliary relay. The function of the relay is set by parameter **704-R1** (see page 41); the default setting is for the relay to activate when the motor is at speed. Terminal NO1 is the normally-open contact, which closes when the relay is activated. Terminal NC1 is the normally-closed contact, which opens when the relay is activated. Terminal RCM1 is the common terminal.

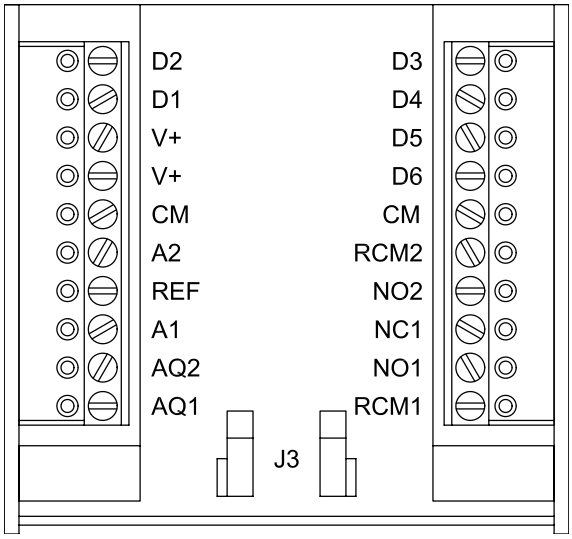


Figure 5
Control Terminals

4.6.2 Typical Connection Diagrams

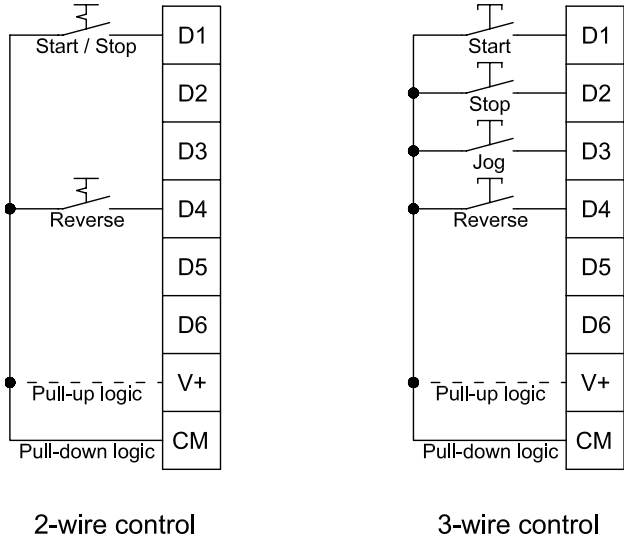


Figure 6
2-wire Control/3-wire Control

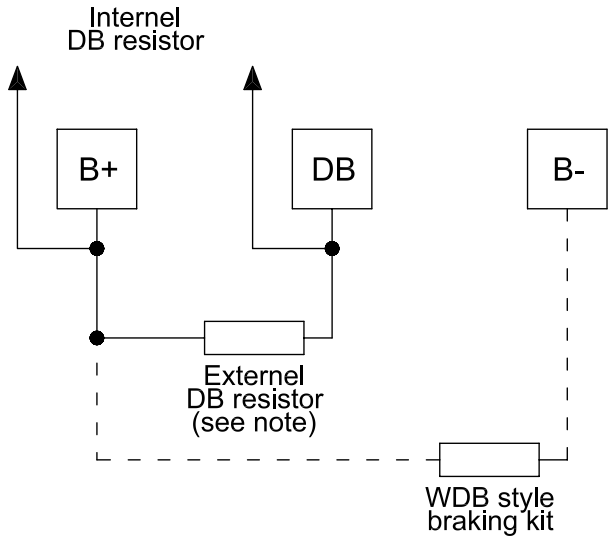


Figure 7
Connections for Dynamic Brake (DB) Options

NOTE:

See Section 4.5 on page 15 for information on selecting and implementing dynamic braking (DB) resistors. If a user-supplied DB resistor is to be used with an EF1 Microdrive, the internal DB resistor must be disconnected and the wires leading to it properly terminated.

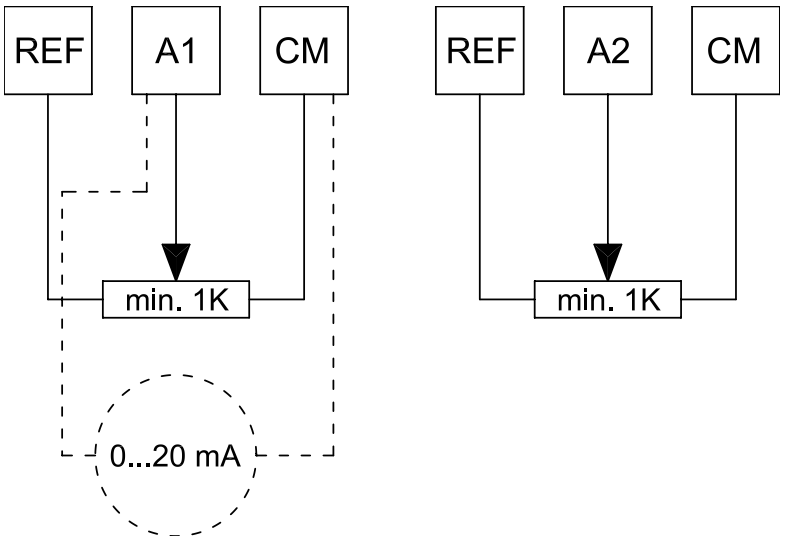


Figure 8
Connections for Analog Inputs

NOTE:

A1 input impedance is 50 ohms when configured for process current input via parameter **205-A1TYP**. The reference point for the target value input (CM) is grounded. This must be taken into account for serial switching of units with control using the target current value.

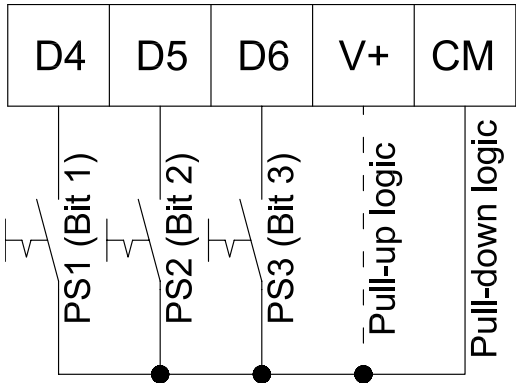


Figure 9
Selection of Preset Speeds

PS3 (Bit 3)	PS2 (Bit 2)	PS1 (Bit 1)	Speed Selected
0	0	0	Normal reference speed as defined by parameters **201-MODE** and **204-FSEL**.
0	0	1	Preset frequency F2 (parameter **303-F2**).
0	1	0	Preset frequency F3 (parameter **304-F3**).
0	1	1	Preset frequency F4 (parameter **305-F4**).
1	0	0	Preset frequency F5 (parameter **306-F5**).
1	0	1	Preset frequency F6 (parameter **307-F6**).
1	1	0	Preset frequency F7 (parameter **308-F7**).
1	1	1	Maximum frequency (parameter **302-FMAX**).

5 Programming with the EF1 Keypad

5.1 Introduction

The EF1 Microdrive is pre-programmed to run a standard, 4-pole AC induction motor. For many applications, the drive is ready for use right out of the box with no additional programming needed. The digital keypad controls all operations of the unit. The eight input keys allow “press and run” operation of the motor (Operation mode) and straightforward programming of the parameters (Program mode).

To simplify programming, the parameters are grouped into two levels:

1. Level 1 is entered by pressing the Program (PROG) key at any time. Level 1 allows you to access the most commonly used parameters.
2. Level 2 is entered by holding down the SHIFT key while pressing the PROG key. Level 2 allows access to all EF1 parameters, including those in Level 1, for applications which require more advanced features.

A list of all parameters and levels is found at the end of these instructions.

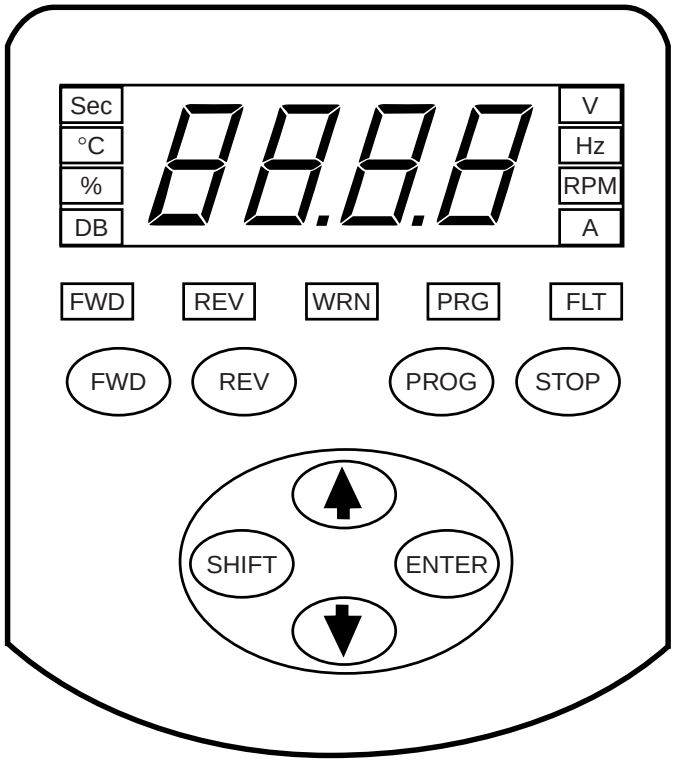


Figure 10
The EF1 Keypad

5.2 Keypad Operation

Parameter **201-MODE** (see page 27) determines whether the EF1 Microdrive accepts its Run/Stop and speed commands from the digital keypad or from the input terminals. The following table describes the function of the keys in Operation mode.

FWD	Initiates forward run when pressed momentarily. If the drive is running in reverse when FWD is pressed, it will decelerate to zero speed, change direction, and accelerate to the set speed.
REV	Initiates reverse run when pressed momentarily. If the drive is running in forward when REV is pressed, it will decelerate to zero speed, change direction, and accelerate to the set speed.
STOP	Causes a Ramp-to-Stop when pressed. Programmable to Coast-to-Stop by parameter **401-RSEL** (page 31).
▲	When the drive is stopped, pressing this key increases the desired running speed. When the drive is running, pressing this key increases the actual running speed. The target values are increased in steps of 0.1 Hz or 0.01 Hz depending on the setting of the parameter **801-PRGNO**. Pressing SHIFT while holding the key bypasses the delay.
▼	When the drive is stopped, pressing this key decreases the desired running speed. When the drive is running, pressing this key decreases the actual running speed. The target values are reduced in steps of 0.1 Hz or 0.01 Hz depending on the setting of the parameter **801-PRGNO**. Pressing SHIFT while holding the key bypasses the delay.
ENTER	When the drive is stopped or running, pressing this key stores the selected frequency as the initial operating frequency when the drive is powered up. The frequency is maintained until another frequency is entered.

Program mode is entered by stopping the EF1 Microdrive and pressing the Program (PROG) key for Level 1 access; or holding down SHIFT while pressing PROG for Level 2 access. The following table describes the function of the keys in Program mode.

PROG	When this key is pressed, the drive enters Program mode and Level 1 parameters are available. (To access Level 2 parameters, hold down SHIFT while pressing this key.) Once the Program mode is active, pressing this key at any time returns the drive to the Operation mode. If an Access Code has been programmed, it must be entered to proceed with programming. See **807-ACODE** (page 44).
▲	In the Program mode, pressing this key scrolls forward through the parameters. If the PRG indicator is flashing, it increases the value of the parameter. The ENTER key must be pressed to store the new value.
▼	In the Program mode, pressing this key scrolls backward through the parameters. If the PRG indicator is flashing, it decreases the value of the parameter. The ENTER key must be pressed to store the new value. **NOTE:** If the PRG indicator is flashing, momentarily pressing and releasing both the UP and DOWN arrows simultaneously will return the parameter to the factory default value. Press ENTER to store the new value.
SHIFT	Pressing this key while a parameter is displayed allows that parameter to have its value changed by use of the UP and DOWN arrow keys. The PRG indicator flashes to show that the parameter can be programmed. Pressing the button again causes the display to jump back one step. Other parameters can now be selected for editing.
ENTER	This key must be pressed after the value of a parameter has been changed to store the new value. The display will show “stored” (STO) for one second indicating that the new value has been entered into memory.

5.3 LED Displays

As shown in Figure 10 on page 20, the digital keypad provides 13 LED indicators. The following table describes what each of these LEDs indicate.

LED	State	Indication
FLT	On	Drive is faulted.
FWD	On	Forward direction commanded.
	Off	Drive is not running in the Forward direction.
REV	On	Reverse direction commanded.
	Off	Drive is not running in the Reverse direction.
PRG	Off	The drive is in Operation mode.
	On	The drive is in Program mode (parameter name displayed).
	Flashing	The value for the parameter may be configured.
WRN [1]	Off	Drive is operating normally.
	On	Fault warning. Drive is running under impermissible conditions which will cause the converter to switch off if not corrected.
Sec	On	The unit of the displayed parameter is seconds.
°C [1]	On	The unit of the displayed parameter is degrees Celsius.
%	On	The value of the displayed parameter is a percentage.
DB	On	Dynamic braking is active.
V	On	The unit of the displayed parameter is volts.
Hz [2]	On	The unit of the displayed parameter is Hertz.
RPM	On	The unit of the displayed parameter is revolutions/minute.
A	On	The unit of the displayed parameter is amperes.

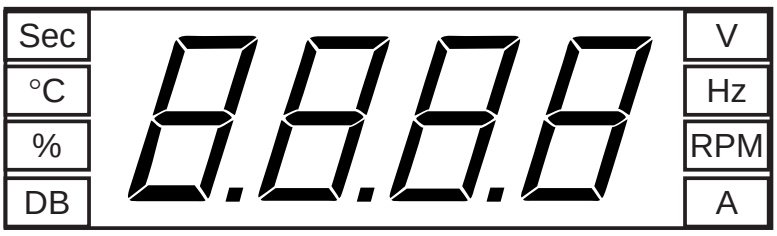
[1] The joint lighting of the WRN and °C-LED's indicates that a motor PTC connected to digital input D6 (setting 19) was triggered due to an overheated motor.

[2] A blinking Hz LED in the operating mode indicates the target frequency (stopped motor) and a constantly lit Hz LED indicates the actual frequency (turning motor).

5.4 Keypad Display Window

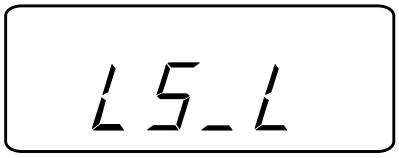
5.4.1 Standard Display

The LED display provides information on drive operation and programming. The four, large 7-segment displays show drive output and programming data. Special symbols provide further information about drive operation (see the following section). The following figure shows all segments displayed. (In normal operation, only active segments are displayed.)

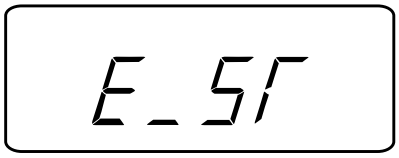


5.4.2 Special Displays

The keypad's display may show special information under certain conditions. The following figures shows these displays and what each indicates:



Line Start Lockout.
See **802-START** on page 42.



Emergency Stop.
See **802-START** on page 42.

Low Voltage.
AC line voltage is too low.

5.5 Programming

5.5.1 Accessing Parameters

When PROG (or SHIFT+PROG) is pressed after the application of power or a fault reset, parameter **201-MODE** is always the first parameter displayed.

If a different parameter is accessed and Program mode is exited, that parameter is the first one displayed the next time Program mode is entered. The drive remembers a different "last parameter accessed" for Levels 1 and 2.

If no key is pressed for 10 minutes while in the Program mode, the drive automatically reverts to the Operation mode.

5.5.2 Changing Display Scroll Rate

Three scroll rates are used to speed data entry:

1. The parameter values are adjusted with the normal speed of change by pressing the UP or DOWN arrows.
2. As soon as one of the arrow keys is pressed after briefly pressing the SHIFT key, the speed is increased by one step.
3. This may be increased by an additional step when the SHIFT key is pressed again while the arrow key is held down.

5.5.3 Programming Procedure

To program the value of a parameter, follow these steps:

1. Press the STOP key if the drive is still running.
2. Press the Program (PROG) key to enter Level 1 Program mode. To enter Level 2, press SHIFT+PROG. The PRG indicator will turn on.
3. Press the UP/DOWN arrow keys to access the desired parameter.

4. Press the SHIFT key. The blinking PRG display now shows that the parameter value can be changed. By pressing this key again, the display jumps back one step. Now additional parameters can be selected for editing without any changes in parameters having been saved.
5. Press the UP/DOWN arrows to select the new value.
6. Press the ENTER key to store the new value. The display shows STO (“stored”) for one second.
7. Call up additional parameters using the UP/DOWN arrow keys or exit the programming mode by pressing the PROG key (to save the changed value, the ENTER key must have been pressed beforehand).

5.5.4 Restoring Factory Settings

Whenever a parameter’s value is being changed (noted by the PRG indicator flashing), the original factory setting for that parameter may be restored by pressing and releasing both the UP and DOWN arrows simultaneously and then pressing the ENTER key.

To restore ALL parameters to factory settings, or to recall a previously stored parameter set, see parameter **801-PRGNO** (page 41).

5.6 Quick Start

The following procedure is for operators with simple applications who would like to get up and running quickly. **Be sure to read and understand Sections 5.1 through 5.5 before proceeding with these instructions.** If you are using remote operators, substitute the speed potentiometer for the UP and DOWN arrows, and the remote Run/Stop switch for the FWD key in the following instructions.

⚠ CAUTION!

IMPROPER EQUIPMENT COORDINATION. Verify that proper voltage is connected to the drive before applying power. **Failure to observe this instruction can result in injury or equipment damage.**

1. Follow all precautions and procedures in Section 3 (Receiving and Installation).
2. Apply AC power to the input terminals. For about two seconds the display will show all segments active. Then, the display will change to all zeros.
3. The factory settings are for keypad only operation in the forward direction – that is, the REV key is disabled. Press the FWD key, which causes the FWD indicator to become lit.
4. Press the UP Arrow to increase the desired running frequency. When the display gets to 0.1 Hz, the drive starts to produce an output.
5. When the motor starts to turn, check the rotation. If the motor is turning in the wrong direction, **press STOP, remove AC power, and wait for all indicators to go out.** After the STATUS indicator has gone out, reverse any two of the motor leads at T1/U, T2/V, or T3/W.
6. The EF1 Microdrive is preset to run a typical NEMA B 4-pole induction motor to a maximum speed of 50.0 Hz with both acceleration and deceleration times set to 3.0 seconds.
7. Use the Arrow keys to set the proper running speed of the motor and the FWD and STOP keys to control its operation.

6 EF1 Parameters

6.1 Introduction

The EF1 Microdrive incorporates a comprehensive set of parameters that allow you to configure the device to meet the special requirements of your particular application.

This chapter describes the available parameters and the values or functions that may be assigned to them. A list of all parameters and levels is found at the end of these operating instructions.

6.2 Level 1 Parameters

The most commonly configured EF1 parameters are stored in a group named Level 1. This group is easily accessed by pressing the PROG key as described in Section 5. The following table lists the parameters in this group; for further information on the parameter, please turn to the indicated page.

Parameter Name	Description	See Page	Parameter Name	Description	See Page
005-FLT5	Most-recent Fault	26	**303-F2**	Preset Frequency 2/ Jog Frequency	30
102-FOUT	Motor Output Frequency	26	**402-ACC1**	Acceleration Time 1	32
103-VOUT	Motor Output Voltage	26	**403-DEC1**	Deceleration Time 1	32
104-IOUT	Motor Output Current	26	**502-BOOST**	Torque Boost	35
105-LOAD	Drive Load	26	**605-SLIP**	Slip Compensation	38
107-TEMP	Drive Temperature	27	**607-TOL**	Timed Overload Trip Point	38
110-WARN	Warning Code	27	**701-METER**	Analog Meter Output AQ1 Selector	40
201-MODE	Input Mode	27	**704-R1**	Relay R1 Selector	41
301-FMIN	Minimum Frequency	30	**705-R2**	Relay R2 Selector	41
302-FMAX	Maximum Frequency	30	**709-MET2**	Analog Meter Output AQ2 Selector	40

6.3 Description of Parameters

002-RVLVL Software Revision Read-Only

Parameter **002-RVLVL**, the AL Software Revision parameter, displays the application layer software version.

◊ Range: –

003-IRAT	Drive Rated Current	Read-Only

Parameter **003-IRAT**, the Drive Rated Current parameter, defines the nominal output current of the EF1 Microdrive. It serves as the 100% reference for all current measurements.

The parameter's value varies by model; see Section 2.2 on page 6.

Continuous drive capacity is 1.1 times the value of this parameter.

◊ Range: varies

005-FLT5	Most-recent Fault	Read-Only
006-FLT4	Second-oldest Fault	Read-Only
007-FLT3	Third-oldest Fault	Read-Only
008-FLT2	Fourth-oldest Fault	Read-Only
009-FLT1	Oldest Fault	Read-Only

These five parameters store the fault code numbers of the last five faults. Parameter **009-FLT1** ("fault 1") contains the fault code of the oldest fault, while parameter **005-FLT5** ("last fault") contains the fault code of the most recent fault.

When one of these parameters is displayed, the value will be of the format "ff.mm", where ff is the fault code number and mm is the number of minutes that have elapsed between the last time the drive was reset and the occurrence of the fault. See Section 7 on page 50 for the list of fault codes and troubleshooting assistance.

◊ Range: –

102-FOUT	Motor Output Frequency	Read-Only

Display of the target frequency of the converter when the start command has been set. This frequency is equivalent to the target value set.

◊ Range: 0...1000 Hz

103-VOUT	Motor Output Voltage	Read-Only

Parameter **103-VOUT**, the Motor Output Voltage parameter, shows the motor output voltage calculated as a percentage of the applied input voltage.

Range: 0...100%

104-IOUT	Motor Output Current	Read-Only

Parameter **104-IOUT**, the Motor Output Current parameter, shows the motor phase-to-phase current computed to an accuracy of ±20%.

◊ Range: 0...60 A

105-LOAD	Drive Load	Read-Only

Parameter **105-LOAD**, the Drive Load parameter, shows the load on the motor (the true part of the motor current) as a percentage of the drive rating.

The output current is measured with the motor power factor applied to an accuracy of ±20%. The parameter value will be positive when the motor is pulling a load ("motoring mode") and negative when being pulled by a load ("regenerative mode").

◊ Range: 0...200%

107-TEMP Drive Temperature Read-Only

Parameter **107-TEMP**, the Drive Temperature parameter, shows the temperature of the drive's heatsink to an accuracy of ±3 °C. When the heatsink temperature exceeds 105 °C (221 °F), the overtemperature fault (fault F50; see page 50 for more information) will occur and the drive will stop.

◊ Range: 0...110 °C

110-WARN Warning Code Read-Only

The value of this parameter indicates whether a warning condition exists. The following are the warning conditions and the code assigned to each:

Data Value	Warning Condition Indicated
0	No warning condition exists.
1	Drive not ready.
2	Internal data error.
3	Drive in torque limit.
4	Low DC bus.
5	Line start lockout active.
6	PTC (parameter **906-D6** must be set to 19 for this to occur).

◊ Range: 0...6

201-MODE Input Mode

Parameter **201-MODE**, the Input Mode parameter, configures the source for speed reference and Run/Stop control input. When programming mode is first accessed, this is the first parameter displayed.

Data Value	Speed Control	Run/Stop Control
0	Keypad	Keypad (Forward only).
1	Analog Input A1	Keypad (Forward only).
2	Keypad	Terminals (2-wire maintained contact).
3	Analog Input A1	Terminals (2-wire maintained contact).
4	Keypad	Terminals (3-wire momentary).
5	Analog Input A1	Terminals (3-wire momentary).
6	EMOP [1] [3]	Terminals (2-wire).
7	EMOP [1] [3]	Terminals (3-wire).
8	EMOP1 [2] [3]	Terminals (2-wire).
9	EMOP1 [2] [3]	Terminals (3-wire).
10	Keypad	Keypad (Forward and Reverse).
11	Analog Input A1	Keypad (Forward and Reverse).

[1] Commanded output frequency returns to the value of parameter **301-FMIN** when the drive is stopped.
[2] Commanded output frequency remains at the previous setpoint when the drive is stopped.
[3] The parameters (**902-D2**...**906-D6**) that set the functions of the designated digital inputs for EMOP must be configured as "Speed+" and "Speed–" (data codes 8 and 9) to complete the implementation. See page 44 for more information.

◊ Range: 0...11 Default = 0

204-FSEL Speed Setpoint Selector

Parameter **204-FSEL**, the Speed Setpoint Selector parameter, configures:

- What input from the terminal strip controls the output frequency (A1 alone, A1 plus A2, A1 minus A2, or selection of A1 or A2 by digital input);
- Whether the signal is offset by the value of parameter **206-A1OFF** or parameter **208-A2OFF**; and
- Whether the signal range is inverted (that is, the minimum input corresponds to the maximum output, while the maximum input corresponds to the minimum output).

The following data values may be assigned to this parameter:

Data Value	Offset	Input Signal
0	No	A1, not inverted.
1	No	A1, inverted.
2	Yes	A1, not inverted.
3	Yes	A1, inverted.
4	No	A1+A2, not inverted.
5	No	A1+A2, inverted.
6	Yes	A1+A2, not inverted.
7	Yes	A1+A2, inverted.
8	No	A1–A2, not inverted.
9	No	A1–A2, inverted.
10	Yes	A1–A2, not inverted.
11	Yes	A1–A2, inverted.
12	No	A1 or A2 by digital input, not inverted [1].
13	No	A1 or A2 by digital input, inverted [1].
14	Yes	A1 or A2 by digital input, not inverted [1].
15	Yes	A1 or A2 by digital input, inverted [1].

[1] The parameter (parameter **902-D2**...**906-D6**) that sets the function of the designated digital input must be configured (data code 13) to complete the implementation. See page 44 for information.

◊ Range: 0...15 Default = 0

205-A1TYP A1 Input Type

Parameter **205-A1TYP**, the A1 Input Type parameter, selects the type of signal for analog input A1. Parameters **206-A1OFF** and **207-A1SPN** may be used to customize the selected range. The following data values may be assigned to this parameter:

Data Value	Input Signal
0	0 to 10 Vdc.
1	0/4 to 20 mAdc (by default, the input signal range is 4 to 20 mAdc; set parameter **206-A1OFF** to 0% to select the 0 to 20 mAdc input signal range).
2	0 to 5 Vdc.

Data Value	Input Signal
3...5	Same as 0–2 except that if the input signal drops below a fixed offset value (for example, if the configured signal is 4 to 20 mAdc and the input signal sinks to 2 mAdc) or, if no offset is configured, the input signal is lost, fault F81 will be generated. See page 51 for more information on this fault.

◊ Range: 0...5 Default = 0

206-A1OFF A1 Offset

Determine the offset for the analogue input A1 (percent value of the programmed maximum value).

Note that if the input signal drops below the offset value or if the input signal is lost (if no offset is configured), fault F81 will be generated. See page 51 for more information on this fault.

◊ Range: 0...100% Default = 20%

207-A1SPN A1 Span

Parameter **207-A1SPN**, the A1 Span parameter, is used to alter the range of the input signal for analog input A1. For example, if parameter **205-A1TYP** selects the 0 to 10 Vdc input signal, setting this parameter to 50% reduces it to 0 to 5 Vdc.

◊ Range: 0...200% Default = 100%

208-A2OFF A2 Offset

Parameter **208-A2OFF**, the A2 Offset parameter, configures the offset for analog input A2 expressed as a percentage of the maximum value of the input signal.

◊ Range: 0...100% Default = 0%

209-A2SPN A2 Span

Parameter **209-A2SPN**, the A2 Span parameter, is used to alter the range of the input signal for analog input A2. For example, if parameter **205-A1TYP** selects the 0 to 10 Vdc input signal, setting this parameter to 50% reduces it to 0 to 5 Vdc.

◊ Range: 0...200% Default = 100%

210-TLSEL Torque Limit Source Selection

Parameter **210-TLSEL**, the Torque Limit Reference Selector, is used to select how the torque limit thresholds in the four quadrants of operation (motoring forward and reverse, regenerative forward and reverse) are set. The following data values may be assigned to this parameter:

Data Value	Source for Torque Limit Thresholds
0	Torque limit thresholds in all quadrants are set via preset values; see parameters **601-LTLF**, **602-LTLR**, **603-RTLF**, and **604-RTLR** starting on page 37 for more information.

Data Value	Source for Torque Limit Thresholds
1	The torque limit threshold when operating in the forward motoring quadrant of operation is controlled by the A2 analog input (with the value of parameter **601-LTLF** acting as the maximum limit). The torque limit thresholds when operating in the other quadrants are set via parameters **602-LTLR**, **603-RTLF**, and **604-RTLR** (see page 37).
2	The torque limit thresholds when operating in the forward and reverse motoring quadrants of operation are controlled by the A2 analog input (with the values of parameters **601-LTLF** and **602-LTLR** acting as the maximum limits for the two quadrants). The torque limit thresholds when operating in the other quadrants are set via parameters **603-RTLF** and **604-RTLR** (see page 37).
3	The torque limit thresholds in all quadrants are controlled by the A2 analog input. The values of parameters **601-LTLF**, **602-LTLR**, **603-RTLF**, and **604-RTLR** act as the maximum limits for each quadrant.

◊ Range: 0...3 Default = 0

301-FMIN Minimum Frequency

Parameter **301-FMIN**, the Minimum Frequency parameter, configures the minimum frequency output by the drive.

◊ Range: 0...1000 Hz Default = 0 Hz

302-FMAX Maximum Frequency

Parameter **302-FMAX**, the Maximum Frequency parameter, configures the maximum frequency output by the drive.

NOTE:

If you want a resolution of 0.01 Hz for this parameter, then Parameter **801-PRGNO** must be set to 150; the maximum frequency, however, is limited to 100 Hz.

◊ Range: 20...1000 Hz Default: 50 Hz

303-F2 Preset Frequency 2/Jog Frequency
304-F3 Preset Frequency F3
305-F4 Preset Frequency F4
306-F5 Preset Frequency F5
307-F6 Preset Frequency F6
308-F7 Preset Frequency F7

These parameters configure six preset speeds in addition to the normal reference speed of the drive (as defined by parameters **201-MODE** and **204-FSEL**) and the maximum frequency of the drive (as set with parameter **302-FMAX**). Thus, in effect, you may choose to operate the drive at up to eight different speeds.

The eight speeds are selected by a combination of three digital inputs. A wiring scheme for utilizing preset speeds is provided on page 19 along with a truth table showing what combination of inputs results in the selection of which speeds.

Note that parameter **303-F2** also serves as the reference frequency for jogging.

Please ensure that if you want a resolution of 0.01 Hz for this parameter, then Parameter **801-PRGNO** must be set to 150; the maximum frequency, however, is limited to 100 Hz.

◊ Parameter **303-F2** Range: 0...1000 Hz Default: 5 Hz
Parameter **304-F3** Range: 0...1000 Hz Default: 20 Hz
Parameter **305-F4** Range: 0...1000 Hz Default: 40 Hz
Parameter **306-F5** Range: 0...1000 Hz Default: 50 Hz
Parameter **307-F6** Range: 0...1000 Hz Default: 0 Hz
Parameter **308-F7** Range: 0...1000 Hz Default: 0 Hz

309-FTL Minimum Frequency When Torque Limit Active

Parameter **309-FTL**, the Minimum Frequency in Torque Limit parameter, sets the minimum frequency when the drive is in motoring torque limit mode.

In torque limit mode, if the calculated torque value exceeds that set in parameters **601-LT-LF** through **604-RTLR** (see page 37), the output frequency will be reduced to the value of parameter **309-FTL** using the deceleration ramp configured by parameter **406-DECTL** (see page 32). If the load is sufficiently large enough to force the drive below the frequency set with this parameter, an overcurrent fault (F65–F69) will occur and the drive will stop. See page 51 for more information on overcurrent faults.

To disable Torque Limit mode, set this parameter to a value greater than or equal to parameter **302-FMAX**.

NOTE:

If you want a resolution of 0.01 Hz for this parameter, then Parameter **801-PRGNO** must be set to 150; the maximum frequency, however, is limited to 100 Hz.

◊ Range: 0...1000 Hz Default: 10 Hz

401-RSEL Ramp Selector

Parameter **401-RSEL**, the Ramp Selector parameter, selects the acceleration and deceleration ramps utilized by the drive, and also whether stops are accomplished by ramping to zero speed or are by coasting. The following data values may be assigned to this parameter:

Data Value	Type of Stop	Ramp Configured by
0	Ramp-to-stop	Parameter **402-ACC1** and **403-DEC1**.
1	Ramp-to-stop	Running Forward: **402-ACC1** and **403-DEC1**. Running Reverse: **404-ACC2** and **405-DEC2**.
2	Ramp-to-stop	If the output frequency is less than preset frequency **307-F6**, the active ramp is set by **402-ACC1** and **403-DEC1**. If the output frequency is equal to or greater than **307-F6**, the active ramp is set by **404-ACC2** and **405-DEC2**.
3	Ramp-to-stop	A digital input is defined as the Alternate Ramp Selector (see page 44). The digital input is then used to select between the ramp configured by **402-ACC1** and **403-DEC1** (digital input false or open) and the ramp configured by **404-ACC2** and **405-DEC2** (digital input true or closed).
4	Coast-to-stop	Same as data value 0.
5	Coast-to-stop	Same as data value 1.
6	Coast-to-stop	Same as data value 2.
7	Coast-to-stop	Same as data value 3.

◊ Range: 0...7 Default: 0

402-ACC1 Acceleration Time 1

Parameter **402-ACC1**, the Acceleration Time 1 parameter, configures the length of time to accelerate from 0 Hz to the value of parameter **302-FMAX**. This acceleration ramp is selected by parameter **401-RSEL**.

Note that extremely short acceleration times may result in nuisance fault trips.

◊ Range: 0.1...600.0 s Default: 3.0 s

403-DEC1 Deceleration Time 1

Parameter **403-DEC1**, the Deceleration Time 1 parameter, configures the length of time to decelerate from the value of parameter **302-FMAX** to 0 Hz. This deceleration ramp is selected by parameter **401-RSEL**.

Note that extremely short deceleration times may result in nuisance fault trips or may require an external dynamic brake.

◊ Range: 0.1...600.0 s Default: 3.0 s

404-ACC2 Acceleration Time 2

Parameter **404-ACC2**, the Acceleration Time 2 parameter, configures the length of time to accelerate from 0 Hz to the value of parameter **302-FMAX**. This acceleration ramp is selected by parameter **401-RSEL**.

Note that extremely short acceleration times may result in nuisance fault trips.

◊ Range: 0.1...600.0 s Default: 1.0 s

405-DEC2 Deceleration Time 2

Parameter **405-DEC2**, the Deceleration Time 2 parameter, configures the length of time to decelerate from the value of parameter **302-FMAX** to 0 Hz. This deceleration ramp is selected by parameter **401-RSEL**.

Note that extremely short deceleration times may result in nuisance fault trips or may require an external dynamic brake.

◊ Range: 0.1...600.0 s Default: 1.0 s

406-DECTL Deceleration Time When Torque Limit Active

Parameter **406-DECTL**, the Deceleration Time in Torque Limit parameter, configures the deceleration ramp when the drive is in Torque Limit mode (see parameter **309-FTL** on page 31 for more information). It also serves as the acceleration ramp when Torque Limit mode is active due to a regenerative condition.

◊ Range: 0.1...600.0 s Default: 1.0 s

407-DCBRK DC Brake Time

Once the means for enabling DC injection braking is activated as configured by parameter **411-DCACT** (see page 33), parameter **407-DCBRK** configures the length of time that DC current will be applied to the motor windings to assist in stopping. The amount of current that is applied is set with parameter **408-DCVLT**.

The following table describes the type of DC braking that is configured by the setting of this parameter:

Data Value	Type of DC Braking Configured
0	DC braking is disabled.
0.1...20.0	Timed DC injection braking is selected. DC current will be applied for the configured amount of time.
20.1	Permanent DC braking – the braking is permanent provided one of the requirements listed as described for parameter **411-DCACT** applies.

◊ Range: 0.0...20.1 s Default: 0.2 s

408-DCVLT DC Brake Voltage

Parameter **408-DCVLT**, the DC Brake Voltage parameter, configures the amount of DC current to be injected into the motor windings during DC injection braking (see parameter **411-DCACT**, page 33). The length of time that the current is applied is set with parameter **407-DCBRK**.

⚠ CAUTION!

MOTOR OVERHEATING. Do not use DC injection braking as a holding brake or excessive motor heating may result. **Failure to observe this instruction can result in equipment damage.**

◊ Range: 0...15% Default: 2/3 of **502-BOOST**

411-DCACT DC Brake Activation

Parameter **411-DCACT**, the DC Brake Activation parameter, is used to select the normal means for enabling DC injection braking. Once enabled, parameter **407-DCBRK** determines when DC injection braking will occur and for how long, while parameter **408-DCVLT** sets the amount of current injected.

The following data values may be assigned to this parameter:

Data Value	DC Injection Braking is Enabled when
0	DC injection braking is not used.
1	A digital input configured for this function becomes true.
2	The output frequency drops below preset frequency F7, which is set with parameter **308-F7**.
3	The active stop ramp is finished.

The following requirements then lead to the triggering of the DC brake:

- Terminal-oriented control and simultaneous setting of the FWD and REV inputs (for setting 0...3, but only for two wire control) or
- Clockwise or anticlockwise rotation with a target value lower than 0.1 Hz (for setting 2...3) or
- A Stop command set and a frequency lower than 0.1 Hz (for setting 2...3).

NOTE:

For 2 wire controls, the DC brake can also be triggered when the setting 0 (no activation) is deactivated by setting the FWD and REV input.

◊ Range: 0...3 Default: 3

412-DBCFG DB Configuration

Parameter **412-DBCFG**, the DB Configuration parameter, determines whether an internal or external dynamic brake (DB), or neither, is utilized. The following data values may be assigned to this parameter:

Data Value	DB Configuration
0	A dynamic brake is not utilized.
1	The internal dynamic brake is utilized.
2	An external dynamic brake is utilized. If this value is selected, parameter **413-EDBDC** becomes available so you may enter the maximum duty cycle of the external dynamic brake.

◊ Range: 0...2 Default: 1

413-EDBDC External DB Maximum Duty Cycle

If parameter **412-DBCFG** is set to data value 2 to select an external dynamic brake, parameter **413-EDBDC**, the External DB Maximum Duty Cycle parameter, becomes available so you may enter the duty cycle of the application (see page 15 for information on calculating the duty cycle).

◊ Range: 0.0...100.0% Default: varies

501-VSEL V/Hz Char. Selector

Parameter **501-VSEL**, the V/Hz Characteristic Selection parameter, determines the characteristic of the V/Hz curve and whether any boost will be applied at starting. (The amount of boost may be automatically determined or set with parameter **502-BOOST**; see page 35.)

The following data values may be assigned to this parameter:

Data Value	V/Hz Curve Configured (see Figure 11 for sample curves)
0	Linear V/Hz curve with auto-boost. This is typically used for constant torque applications; however, do not use it for multimotor applications. The amount of boost applied varies from zero to the value of **502-BOOST** and is calculated by the drive based on the load.
1	Linear V/Hz curve with the amount of boost fixed at the value set in parameter **502-BOOST**.
2	Mixed (quadratic and linear) V/Hz curve with auto-boost. This is typically used for pump applications.
3	Mixed (quadratic and linear) V/Hz curve with the amount of boost fixed at the value set in parameter **502-BOOST**.
4	Quadratic V/Hz curve with auto-boost. This is typically used for applications involving fans.
5	Quadratic V/Hz curve with the amount of boost fixed at the value set in parameter **502-BOOST**.
6 [1]	Activates parameters **510-VHZ1F**, **511-VHZ1V**, **512-VHZ2F**, **513-VHZ2V**, **514-VHZ3F**, and **515-VHZ3V** (which are described on page 37). These parameters are used to define three points through which the V/Hz curve passes so a custom curve may be created for special motor applications. Figure 12 on page 35 illustrates how these parameters define a custom V/Hz curve.

[1] This menu entry is only visible when parameter **801-PRGNO** is set to 160.

◊ Range: 0...5...6 Default: 0

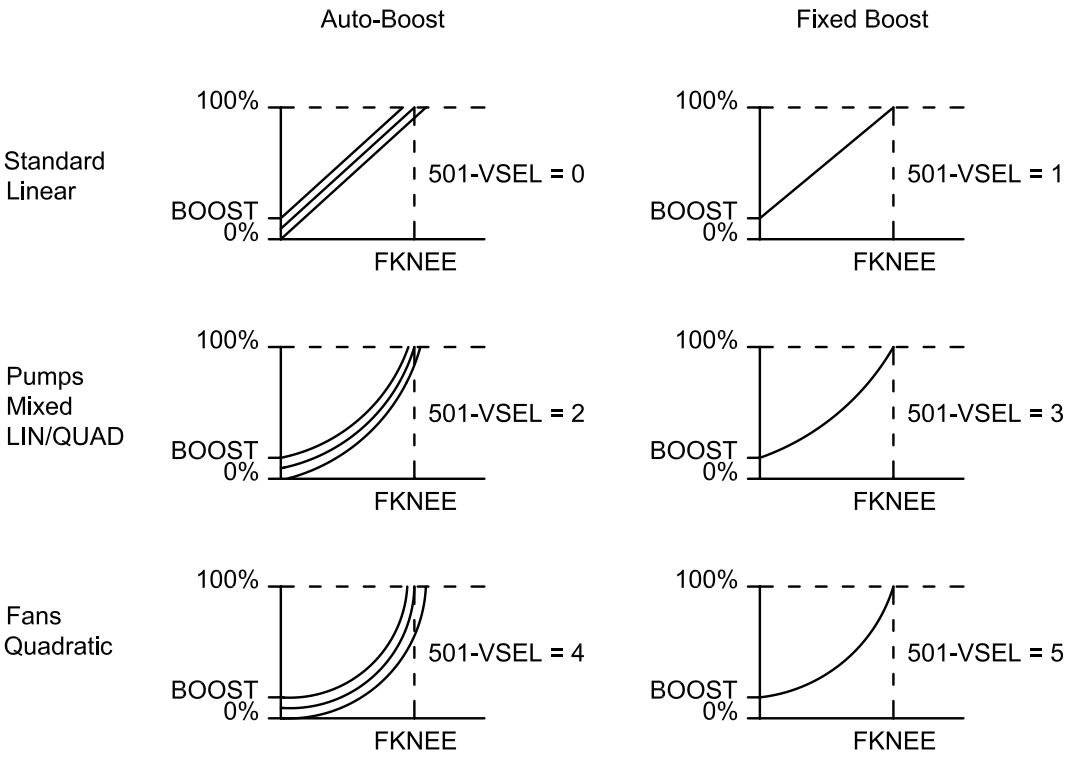


Figure 11
V/Hz Characteristics Configured by Parameter 501-VSEL

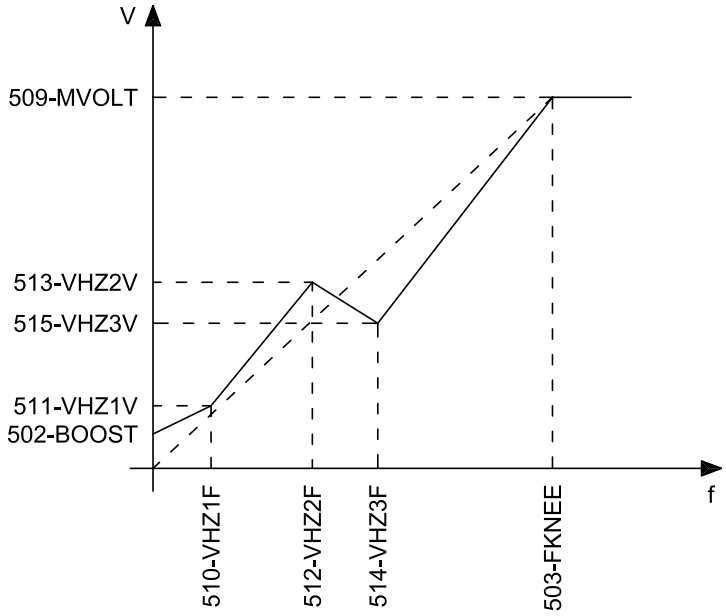


Figure 12
Custom V/Hz Characteristic Curve (501-VSEL = 6)

502-BOOST Torque Boost

Parameter **502-BOOST**, the Torque Boost parameter, increases the motor voltage at low speed to increase the starting torque of the motor. The amount of boost decreases linearly with increasing speed.

Parameter **501-VSEL** determines whether the amount of boost configured in this parameter is always applied or serves as the maximum value for the automatic determination of boost by the drive.

⚠ CAUTION!

MOTOR OVERHEATING. Too much boost may cause excessive motor currents and motor overheating. Use only as much boost as is necessary to start the motor. Auto-boost may be selected at parameter **501-VSEL** to provide optimum value of boost to suit the load automatically. **Failure to observe this instruction can result in equipment damage.**

◊ Range: 0...25% Default: Model dependent

503-FKNEE V/Hz Knee Frequency

Knee frequency. This frequency defines the point on the frequency scale where the output voltage reaches the value of the real input voltage – under consideration of the setting in parameter **509-MVOLT**.

This value should be equivalent to the nominal frequency of the motor when using AC motors. In the case of special motors, it may be higher in order to achieve constant torque over a larger range. A higher value selected for **503-FKNEE** can lead to minor motor losses at low frequencies.

◊ Range: 30...1000 Hz Default: 50 Hz

504-SKBND Skip Frequency Band

To reduce mechanical resonances in a drive system, the drive may be configured to “skip” certain frequencies. Once configured, the drive will accelerate or decelerate through the prohibited frequency band without settling on any frequency in the band. The EF1 Microdrive provides the capability to configure three prohibited frequency bands.

Parameter **504-SKBND**, the Skip Frequency Band parameter, sets the width of the band above and below each of the prohibited frequencies set in parameters **505-SK1**, **506-SK2**, and **507-SK3**.

For example, if this parameter is set to its default value of 1 Hz and parameter **505-SK1** is set to 20 Hz, a skip band from 19 to 21 Hz is established.

◊ Range: 0.2...20.0 Hz Default: 1 Hz

505-SK1 Skip Frequency 1

506-SK2 Skip Frequency 2

507-SK3 Skip Frequency 3

As discussed in the description of parameter **504-SKBND** above, the drive may be configured to skip certain frequencies. These three parameters set the center of the three skip frequency bands (with the width of each band being twice the value of parameter **504-SKBND** – an equal amount above and below the skip frequency).

For example, if parameter **504-SKBND** is set to 2.5 Hz and parameter **507-SK3** is set to 55 Hz, a skip band from 52.5 to 57.5 Hz is established.

NOTE:

If you want a resolution of 0.01 Hz for this parameter, then you must set the parameter **801-PRGNO** to 150; the maximum frequency, however, is limited to 100 Hz.

◊ Range: 0.0...1000.0 Hz Default: 0.0 Hz

508-MNLP Motor Saturation

Determination of the starting point for the slip compensation. The slip compensation is only used above the idle current defined here.

This adjustment must take place while the motor that is driven is idling. The value in this parameter is to be reduced in small steps until the parameter **105-LOAD** displays a value near 0% during idling.

◊ Range: 15...85% Default: Model dependent

509-MVOLT Rated Motor Voltage

Setting the nominal motor voltage, i.e. the maximum output voltage for the converter which is output to the motor when the knee frequency is reached (parameter **503-FKNEE**).

◊ Range: Model dependent Default: Model dependent

510-VHZ1F V/Hz Frequency, Point 1

511-VHZ1V V/Hz Voltage, Point 1

512-VHZ2F V/Hz Frequency, Point 2

513-VHZ2V V/Hz Voltage, Point 2

514-VHZ3F V/Hz Frequency, Point 3

515-VHZ3V V/Hz Voltage, Point 3

Note that by default these parameters are hidden, and the standard V/Hz curve is utilized (see Figure 11 on page 35). To create a custom V/Hz curve and make these parameters available, set parameter **501-VSEL** to data value 6 and parameter **801-PRGNO** to data value 160 (see page 41 for more information). (Also note that if parameter **801-PRGNO** is set to data value 160 a second time, the parameters will again become inaccessible.)

If desired, the V/Hz curve may be customized by setting three points through which the curve will pass. Each point is a [frequency, voltage] coordinate. Parameters **510-VHZ1F** and **511-VHZ1V** set the first coordinate; parameters **512-VHZ2F** and **513-VHZ2V** set the second coordinate; and parameters **514-VHZ3F** and **515-VHZ3V** set the third and final coordinate. Figure 12 on page 35 illustrates how these parameters define a custom V/Hz curve.

As soon as the frequency value in a parameter of a coordinate pair has been set to 0 (e.g. parameter **512-VHZ2F**), the characteristic curve moves through the range from point 1 directly to point 3.

◊

Parameter **510-VHZ1F**	Range: 0...1000 Hz	Default: 0 Hz
Parameter **511-VHZ1V**	Range: 0...100%	Default: 0 Vac
Parameter **512-VHZ2F**	Range: 0...1000 Hz	Default: 0 Hz
Parameter **513-VHZ2V**	Range: 0...100%	Default: 0 Vac
Parameter **514-VHZ3F**	Range: 0...1000 Hz	Default: 0 Hz
Parameter **515-VHZ3V**	Range: 0...100%	Default: 0 Vac

601-LTLF Limit for Torque Load (Forward)

602-LTLR Limit for Torque Load (Reverse)

When parameter **309-FTL** is set to a value less than or equal to parameter **302-FMAX**, torque limiting is activated (see page 31).

Provided that parameter **210-TLSEL** is set appropriately (see page 29), these two parameters configure the point at which torque limiting will occur when the drive is in motoring mode (that is, driving a load), with individual settings for forward (**601-LTLF**) and reverse (**602-LTLR**) operation. The value is a percentage of nominal motor torque.

◊ Range: 30...150% Default: 150%

603-RTLF Limit for Regen. Torque (Forward)

604-RTLR Limit for Regen. Torque (Reverse)

When parameter **309-FTL** is set to a value less than or equal to parameter **302-FMAX**, torque limiting is activated (see page 31).

Provided that parameter **210-TLSEL** is set appropriately (see page 29), these two parameters configure the point at which torque limiting will occur when the drive is in regenerative mode (that is, being driven by a load), with individual settings for forward (**603-RTLF**) and reverse (**604-RTLR**) operation. The value is a percentage of nominal motor torque.

◊ Range: 30...110% Default: 80%

605-SLIP Slip Compensation

Parameter **605-SLIP**, the Slip Compensation parameter, allows you to compensate for slip in standard NEMA-rated induction motors. Do not set use slip compensation if the drive is connected to a synchronous motor because gross instability may result. Slip compensation is automatically turned off if the PI Regulator function is enabled.

The assigned value for this parameter may range from 0.0 to 12.0%, with a setting of 0.0% causing slip compensation to be inactive. Use the following formula to calculate the value for parameter **605-SLIP**:

$$\text{Parameter 605-SLIP} = \frac{(\text{Synch. Speed} - \text{Nameplate Speed})}{\text{Synch. Speed}} \times \frac{\text{Value of Par. 003-IRAT}}{\text{Motor Nameplate Current}} \times 100$$

◊ Range: 0.0...12.0% Default: 0.0%

607-TOL Timed Overload Trip Point

610-TOLC Timed Overload Characteristic

These parameters define the amount of load (parameter **607-TOL**, expressed as a percentage of nominal motor current) and the length of time that the load is applied (parameter **610-TOLC**) for a timed electronic trip to occur. To derive a value for parameter **607-TOL**, use the following formula (see page 26 for the values of parameter **003-IRAT**):

$$\text{Parameter 607-TOL} = \frac{\text{Motor Nameplate Current}}{\text{Value of Parameter 003-IRAT}} \times 100$$

NOTE: set this parameter to zero to disable the timed electronic trip function.

For parameter **610-TOLC**, set it to one of the following data values to configure the desired overload characteristic:

Data Value	Tripping Characteristic [1]	Time Scale in Figure 13	Motor Type
0	Normal [2]	C	Standard induction
1	Medium [2]	B	Standard induction
2	Fast [2]	A	Standard induction
3	Shear pin [3]	—	Standard induction
4	Normal [2]	C	Inverter duty

Data Value	Tripping Characteristic [1]	Time Scale in Figure 13	Motor Type
5	Medium [2]	B	Inverter duty
6	Fast [2]	A	Inverter duty
7	Shear pin [3]	—	Inverter duty

[1] Data values 0–3 have reduced thresholds below 40 Hz; values 4–7 follow the 40 Hz curve at any speed.
[2] Trip time at 150% of **607-TOL** setting is 60 s for Normal, 30 s for Medium, and 6 s for Fast.
[3] Trip time at 110% of **607-TOL** setting is instantaneous for shear pin effect.

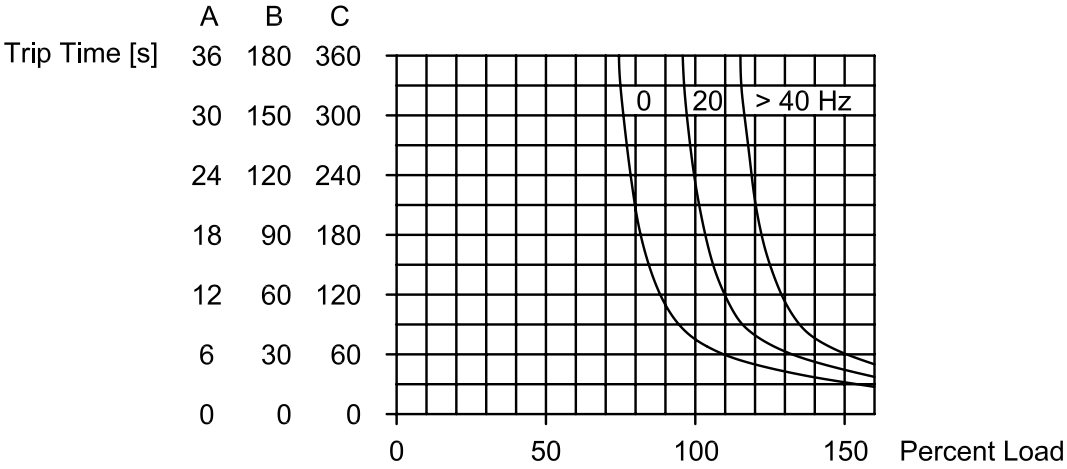


Figure 13
Timed Overload Trip Point

◊ Parameter **607-TOL** Range: 0...100% Default: 100%
Parameter **610-TOLC** Range: 0...7 Default: 0

608-NRST Trip Restart – Number of Attempts
609-DRST Trip Restart – Time Delay

You may configure the drive to attempt to re-start a specified number of times after certain faults occur. Section 7, starting on page 50, lists all faults and notes which ones may be reset automatically.

The number of attempts at re-starting is set with parameter **608-NRST** (a value of 0 prevents the drive from attempting a re-start). The time duration that must elapse between re-start attempts is set with parameter **609-DRST**.

If the number of attempted re-starts is exceeded, the drive will trip with fault F90 and stop operating. **Resetting the fault can result in instant starting. (See page 51 for more information on fault F90).**

Note that for 2-wire operation, the FWD or REV terminal must still be active for the drive to attempt a re-start.

Also note that the counter for attempted re-starts will not reset to zero until ten minutes after a successful re-start.

⚠ CAUTION!

UNINTENDED EQUIPMENT ACTION! Ensure that automatic re-starting will not cause injury to personnel or damage to equipment. **Failure to observe this instruction can result in serious injury or equipment damage.**

◊ Parameter **608-NRST** Range: 0...8 Default: 0 tries (disabled)
Parameter **609-DRST** Range: 0.0...60.0 s Default: 0.1 s

614-RGNSTOP Permitted Time in Regenerative Current Limit

This parameter sets the limit to the amount of time that the drive may continue to run in regenerative current limit mode after a Stop command is issued. If the configured time duration expires and the drive is not at zero speed, fault F91 is generated and the drive coasts to a stop. See page 51 for information about fault F91.

◊ Range: 0.0...5.0 s Default: 1.0 s

620-PHLOSS Phase Loss Detection

Parameter **620-PHLOSS**, the Phase Loss Detection parameter, may be configured to monitor line power for phase loss. When enabled (by default it is inactive), if the loss of a phase is detected, fault F40 is generated and the drive coasts to a stop. See page 50 for further information about fault F40.

◊ Range: 0...1 Default: 0 (inactive)

701-METER Analog Meter Output AQ1 Selector

709-MET2 Analog Meter Output AQ2 Selector

These parameters select the analog output signal sent from terminal AQ1 and AQ2, respectively. The default full-scale setting is 0–10 Vdc on AQ1 or 0–20 mAdc on AQ2, but this may be changed by using parameters **702-M1OFF** and **703-M1SPN** (for AQ1) or parameters **710-M2OFF** and **711-M2SPN** (for AQ2).

The following data values may be assigned to these parameters:

Data Value	Analog Output Signal Is Proportional to
0	AQ1/AQ2 is not utilized.
1	Output frequency (**102-FOUT**), with full scale at **302-FMAX**.
2	Output current (**104-IOUT**), with full scale at 300% of rated current (value of parameter **003-IRAT**).
3	Load (**105-LOAD**), with full scale at 300% of rated load.
4	Output voltage (**103-VOUT**), with full scale at 150% of input voltage.
5	Calculated stator frequency.
6	Drive temperature (**107-TEMP**).
10...16	Same as 0 through 6, but with an offset. Use parameters **702-M1OFF** (for AQ1) and **710-M2OFF** (for AQ2) to set the amount of offset.

◊ Parameter **701-METER** Range: 0...16 Default: 1
Parameter **709-MET2** Range: 0...16 Default: 3

702-M1OFF AQ1 Offset

710-M2OFF AQ2 Offset

If parameter **701-METER** or **709-MET2** is set to a value between 10 and 16, these parameters become available and configure the amount of offset for AQ1 and AQ2, respectively, expressed as a percentage of the maximum value of the output signal.

◊ Parameter **702-M1OFF** Range: 0...100% Default: 20%
Parameter **710-M2OFF** Range: 0...100% Default: 20%

703-M1SPN AQ1 Span

711-M2SPN AQ2 Span

If parameter **701-METER** or **709-MET2** is set to a value between 10 and 16, these parameters become available and are used to configure the range (span) of AQ1 and AQ2, respectively. The values of the parameters are expressed as a percentage of the maximum value of the output signal.

◊ Parameter **703-M1SPN** Range: 0...200% Default: 100%
Parameter **711-M2SPN** Range: 0...200% Default: 100%

704-R1 Relay R1 Selector

705-R2 Relay R2 Selector

These parameters configure what condition causes relay R1 and R2 to activate. The following data values may be assigned to these parameters:

Data Value	Relay Activates When
0	Relay is not used.
1	The drive is ready. (The relay will be open in Fault and Low Voltage conditions.)
2	As soon as an alarm occurs [1].
3	When the start command is set.
4	The motor is running in Reverse and the output frequency is above 0.5 Hz.
5	The motor is running Forward and the output frequency is above 0.5 Hz.
6	The output frequency is above 0.5 Hz.
7	The motor is running at the commanded speed.
8	The output frequency is greater than preset frequency F5 (which is set with parameter **306-F5**).
9	The drive is operating in torque limit.
10	The heatsink temperature is within 10 °C of the maximum temperature (overtemperature warning).
11	When a motor PTC connected to a digital input D6 reports an overheating motor (see page 44, setting 19).

[1] When an alarm has occurred which can be reset by the auto-reset function (automatic restart try, see page 39) or while the automatic restart is occurring, the relay remains dropped out.

◊ Parameter **704-R1** Range: 0...11 Default: 2
Parameter **705-R2** Range: 0...11 Default: 6

801-PRGNO Special Program

Setting and assigning special functions. After execution of a special function, this parameter is automatically reset to 0.

The following data values may be assigned to this parameter:

Data Value	Special Function Configured
0	Standard program.
1	Reset all parameters to factory default values (display = SETP) [1].
2	Store custom parameter values (display = STOC) [1].
3	Recall custom parameter values (display = SETC) [1].
80	Enable PI control. When this value is entered and saved, and then Program mode is exited and re-entered, the PI adjustment parameters (parameters **910-FSTAT**, **911-FCORR** and **912-ERROR2** through **918-PICFG**) will become available.
150	Switching both the maximum value of the frequency parameter (0...1000 Hz or 0...100 Hz) and the resolution of the display. At 0...1000 Hz the resolution is 0.1 Hz, at 0...100 Hz it is increased to 0.01 Hz.
160	You can access the parameter to define an application-specific 3 point V/Hz characteristic curve by setting this value (see page 37).

[1] This display only appears after exiting the program mode.

◊ Range: 0...255 Default: 0

802-START Start Options

Parameter **802-START**, the Start Options parameter, configures the type of start to be performed. It also determines whether the STOP key on the keypad functions as an emergency stop when the terminal strip is the active control source and whether the drive will trip if Modbus serial communication is lost. See page 23 for special display indications used with this parameter.

The following data values may be assigned to this parameter:

Data Value	Type of Start and Stop Configured
0	Line Start Lockout. If maintained contact run operators are used, they must be opened and then re-closed for the drive to start after AC power is applied. If parameter **201-MODE** is set to a data value between 2 and 9 (see page 27), the STOP key may be used as an emergency stop, with a coast-to-stop being performed. (To recover from an emergency stop, press the STOP key again.) The drive will not stop if the connection to J3 is lost.
1	Auto-Start. When AC power is applied, if a Run command is present through the terminal strip, the drive will start. Otherwise, the same as data value 0.
2	Start into a rotating motor with Line Start Lockout. Otherwise, the same as data value 0.
3	Start into a rotating motor with Auto-Start. Otherwise, the same as data value 0.
4...7	Same as data values 0 through 3 except that the STOP key on the keypad is disabled if the Start/Stop control source is defined as the terminal strip by parameter **201-MODE**.
8...11	Same as data values 0 through 3 except that the drive will stop when the serial link watchdog timer (parameter **954-MBTO**, see page 48) times out.

◊ Range: 0...11 Default: 0

803-PWM PWM Carrier Frequency

Parameter **803-PWM**, the PWM Carrier Frequency parameter, sets the carrier frequency of the Pulse-Width Modulation (PWM) waveform supplied to the motor. Low carrier frequencies provide better low-end torque, but produce some audible noise from the motor. Higher carrier frequencies produce less audible noise, but cause more heating in the drive and motor.

The EF1 Microdrive is rated to produce continuous full-load current at rated temperatures when **803-PWM** is set to the default value of 6 kHz. Data value 0 (Autoselect) automatically selects the highest carrier frequency possible without overheating the drive.

The following data values may be assigned to this parameter:

Data Value	Carrier Frequency Configured
0	Autoselect [1].
1	4 kHz.
2	6 kHz.
3	8 kHz.
4	12 kHz [2].
5	16 kHz [2].

[1] The carrier frequency is 16 KHz when you select “Auto-Select” and is automatically switched to 8 KHz when either the nominal output of the converter or a converter temperature of more than 90° C is reached. The carrier frequency is reduced by one of the given carrier frequency steps (6 kHz, 4 kHz) for each further increase of 2° C. When the temperature declines below this threshold, then the unit switches back to the previous frequency.

[2] The 12 and 16 kHz levels automatically shift to 6 and 8 kHz, respectively, and then to 4 kHz if derating is exceeded.

Consult factory for further information.

◊ Range: 0...5 Default: 2

804-DISP Display Option Setting

Parameter **804-DISP**, the Display Option Setting parameter, defines the information to be displayed on the keypad during Run operation. The following data values may be assigned to this parameter:

Data Value	In Run, Display Shows
0	Output frequency in Hz (**102-FOUT**).
1	Output current in A (**104-IOUT**).
2	Load as a percentage of nominal (**105-LOAD**).
3	Stator frequency; see parameter **701-METER** on page 40.
4...3000	Revolutions per minute. To determine the data value, multiply the desired rpm value to be displayed by (20 divided by the value of **102-FOUT**). For example, to display 1500 rpm at 50 Hz, the data value is equal to 1500 × (20/50) = 600.

◊ Range: 0...3000 Default: 0

807-ACODE Security Access Code

An access right for all parameters is issued by entering a value from 1...999. After assigning an access or security code, “000” appears in the display when the programming mode is called up.

However, to continue, you must enter the value of parameter **807-ACODE**. Once the correct security code is entered, the display will return to the normal Program mode display. From the last keystroke, you now have ten minutes in which to perform programming tasks unless power is lost or interrupted. After ten minutes expire, you must re-enter the security code.

◊ Range: 0...999 Default: 0

901-PUPD DI Logic

Parameter **901-PUPD**, the Pull-up/Pull-down Logic for Digital Inputs parameter, configures whether pull-up or pull-down control logic is utilized for the digital inputs. The following data values may be assigned to this parameter:

Data Value	Type of Logic
0	Pull-down.
1	Pull-up.

◊ Range: 0...1 Default: 1

902-D2 D2 Selector
903-D3 D3 Selector
904-D4 D4 Selector
905-D5 D5 Selector
906-D6 D6 Selector

These parameters configure the functions performed by digital inputs D2 through D6. The following data values may be assigned to this parameter:

Data Value	Function Performed by Digital Input (DI) [1]
0	Digital input Dx is not utilized.
1	Command Reverse.
2	Change direction of rotation. (For example, if the motor is running in Reverse, momentarily activating the DI with this setting will cause the motor to decelerate to zero speed and then run Forward.)
3	Preset speed selection – bit 1.
4	Preset speed selection – bit 2.
5	Preset speed selection – bit 3.
6	Select alternate acceleration and deceleration ramp.
7	Activate DC injection braking.
8	When EMOP speed control is used, increase reference speed [2].
9	When EMOP speed control is used, decrease reference speed [2].
10	Stop using coast-to-stop deceleration if DI is true (closed).
11	Stop using coast-to-stop deceleration if DI is false (open).

Data Value	Function Performed by Digital Input (DI) [1]
12	Run/Jog (reference speed set by **303-F2**).
13	Switching the analogue inputs A1 and A2 [3].
14	Toggle PI control on and off. See parameter **918-PICFG** on page 46 for more information.
15	Fault reset.
16	Normally-open external fault input. Generates fault F70; see page 51 for more information on this fault.
17	Normally-closed external fault input. Generates fault F70; see page 51 for more information on this fault.
18	Only for D6: PTC input (fault F71; see page 51 for more information on this fault).
19	Only for D6: PTC input (warning).

[1] If a 2-wire control scheme is utilized, digital input D2 may be assigned any function. However, if 3-wire control is utilized, D2 is automatically configured as the Stop input and cannot be set to another function.
[2] See data codes 6/7 or 8/9 of parameter **201-MODE** on page 27 for further information.
[3] See data codes 12–15 of parameter **204-FSEL** on page 28 for further information.

◊ Parameter **902-D2** Range: 0...19 Default: 1
Parameter **903-D3** Range: 0...19 Default: 3
Parameter **904-D4** Range: 0...19 Default: 4
Parameter **905-D5** Range: 0...19 Default: 5
Parameter **906-D6** Range: 0...19 Default: 7

909-RVLVL2 FL Revision Read-Only

Parameter **909-RVLVL2**, the FL Software Revision parameter, shows the fundamental layer software revision number.

◊ Range: –

910-FSTAT Stator Frequency Read-Only

Once parameter **801-PRGNO** is set to 80 to activate the PI feedback set-up parameters, parameter **910-FSTAT** (the Stator Frequency parameter) becomes available and shows the stator frequency.

◊ Range: 0...1000 Hz

911-FCORR Frequency Correction

Parameter **911-FCORR**, the Frequency Correction parameter, is only available when parameter **801-PRGNO** is set to data value 80 (invokes PI feedback mode).

When available, it sets the limits of correction that may be imposed on the operating frequency of the drive. This is of benefit because it limits the response of the drive if feedback is lost.

◊ Range: 0...1000 Hz Default: 0

912-ERROR2 Final Error Read-Only

913-ERROR1 Initial Error Read-Only

914-SIPART Integral Sum Read-Only

915-KP Proportional Gain

916-KI	Integral Gain
917-KIN	A2 Gain
918-PICFG	PI Configuration

When parameter **801-PRGNO** is set to value 80, PI (proportional integral) control is enabled and parameters **912-ERROR2** through **918-PICFG** become available.

Parameter **918-PICFG** configures the type of PI control: direct- or reverse-acting loop (in a direct-acting loop, a positive error causes an increase in output frequency, while a reverse-acting loop decreases the output frequency); slow or fast rate of integration; whether feed-forward is active (it should be selected for speed loop applications since the reference value has a direct relation to the feedback signal); and whether PI control may be enabled via a digital input. The following data values may be assigned to this parameter:

Data Value	Loop Type	Rate	Feed-Forward	Enable by DI
0	Direct-acting	Slow	Yes	No
1	Direct-acting	Fast	Yes	No
2	Reverse-acting	Slow	Yes	No
3	Reverse-acting	Fast	Yes	No
4	Direct-acting	Slow	Yes	Yes
5	Direct-acting	Fast	Yes	Yes
6	Reverse-acting	Slow	Yes	Yes
7	Reverse-acting	Fast	Yes	Yes
8	Direct-acting	Slow	No	No
9	Direct-acting	Fast	No	No
10	Reverse-acting	Slow	No	No
11	Reverse-acting	Fast	No	No
12	Direct-acting	Slow	No	Yes
13	Direct-acting	Fast	No	Yes
14	Reverse-acting	Slow	No	Yes
15	Reverse-acting	Fast	No	Yes

The remaining configurable parameters are used to adjust proportional gain (**915-KP**), integral gain (**916-KI**), and scaling for the feedback terminal (**917-KIN**).

The Read-Only parameters provide information about the PI process: parameter **912-ERROR2** is the final error, parameter **913-ERROR1** is the initial error, and parameter **914-SIPART** is the sum of the integral term of the PI regulator.

See chapter 9 on page 53 for further information on PI control.

◊	Parameter **912-ERROR2**	Range: varies	Read-Only
	Parameter **913-ERROR1**	Range: varies	Read-Only
	Parameter **914-SIPART**	Range: varies	Read-Only
	Parameter **915-KP**	Range: 0...255	Default: 0
	Parameter **916-KI**	Range: 0...255	Default: 0
	Parameter **917-KIN**	Range: 0...255	Default: 0
	Parameter **918-PICFG**	Range: 0...15	Default: 0

950-MBPROT Modbus Protocol

Parameter **950-MBPROT**, the Modbus Protocol parameter, configures the type of Modbus protocol to be used, either RTU or ASCII. The following data values may be assigned to this parameter:

Data Value	Type of Protocol
0	RTU (Parameter **952-MBPAR**, setting 1...3).
1	ASCII (Parameter **952-MBPAR**, setting 4...6).

◊ Range: 0...1 Default: 0

951-MBBAUD Baud Rate

Parameter **951-MBBAUD**, the Modbus Baudrate parameter, configures the baud rate for Modbus communication. The following data values may be assigned to this parameter:

Data Value	Baud Rate Configured (bps)
0	Serial communication is not utilized.
1	1200.
2	4800.
3	9600.
4	19200.

◊ Range: 0...4 Default: 3

952-MBPAR Parity

Parameter **952-MBPAR**, the Modbus Parity parameter, configures the parity for Modbus communication. The following data values may be assigned to this parameter:

Data Value	Type of Parity
0	No parity, 8 data bits, 1 stop bit.
1	RTU mode: No parity, 8 data bits, 2 stop bits.
2	RTU mode: Even parity, 8 data bits, 1 stop bit.
3	RTU mode: Odd parity, 8 data bits, 1 stop bit.
4	ASCII mode: No parity, 7 data bits, 2 stop bits.
5	ASCII mode: Even parity, 7 data bits, 1 stop bit.
6	ASCII mode: Odd parity, 7 data bits, 1 stop bit.

◊ Range: 0...6 Default: 0

953-MBDROP Drop Number

Parameter **953-MBDROP**, the Modbus Drop Number parameter, stores the address (drop number) of the drive.

◊ Range: 1...247 Default: 1

954-MBTO Watchdog Timer

Parameter **954-MBTO**, the Watchdog Timer parameter, configures the length of time in which the drive must receive a valid Modbus telegram. (Valid telegrams need not be addressed to a specific drive.) If a valid telegram is not received in the configured amount of time, then fault F72 will occur and the drive will coast to a stop. See page 51 for more information on this fault.

◊ Range: 1.0...60.0 s Default: 1.0 s

960-STAT1 Status Word 1 Read-Only

Serial communication may be used to read parameter **960-STAT1** (the Status Word 1 parameter) to gather status information about the drive. The bits of the word represented by this parameter provide the following information:

							+0								+1
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Bit	When Set to 1 Signifies	Bit	When Set to 1 Signifies
8	Alternate ramp 2 is active	0	Serial link control active
9	not used	1	Frequency set via serial link
10	not used	2	Drive is running in Forward
11	Keypad is in control	3	Drive is running in Reverse
12	DC injection braking is active	4	FEXT2 is active serial link reference
13	not used	5	Drive is accelerating
14	Run commanded, but no reference	6	Drive is decelerating
15	Drive is faulted (locked-out)	7	Drive is at speed

◊ Range: 0...65535

961-STAT2 Status Word 2 Read-Only

Serial communication may be used to read parameter **961-STAT2** (the Status Word 2 parameter) to gather status information about the drive. The bits of the word represented by this parameter provide the following information:

							+0							+1
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Bit	When Set to 1 Signifies	Bit	When Set to 1 Signifies
8	not used	0	Drive is ready to run
9	not used	1	Drive is in Program mode
10	not used	2	not used
11	not used	3	not used
12	not used	4	not used
13	Drive is in the undervoltage state	5	Drive is operating in Torque Limit
14	Overtemperature warning	6	not used
15	Drive is faulted (not locked-out)	7	not used

◊ Range: 0...65535

962-CNTL1 Control Word 1

Modbus Write commands may be used to control the drive via the serial link by setting the bits of parameter **962-CNTL1** (the Control Word 1 parameter) appropriately. The bits of the word represented by this parameter perform the following actions:

							+0							+1	
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Bit	When Set to 1 Signifies	Bit	When Set to 1 Signifies
8	Command Alternate Ramp #2	0	Initiate serial link control
9	not used	1	Set ref. frequency by serial link
10	not used	2	Command Forward direction
11	not used	3	Command Reverse direction
12	Initiate DC injection braking	4	Use FEXT2 value as ref. frequency
13	Perform a coast-to-stop	5	Command Preset Speed (bit 1)
14	not used	6	Command Preset Speed (bit 2)
15	Alarm or serial connection reset	7	Command Preset Speed (bit 3)

◊ Range: 0...65535 Default: 0000

963-FEXT1 External Frequency Reference 1

964-FEXT2 External Frequency Reference 2

These parameters store two frequency values, each of which may be selected to be the active speed reference when the frequency is set via the serial link.

◊ Range: 0...1000 Hz Default: 0 Hz

7 Troubleshooting

The following table shows the fault codes that may be displayed, along with suggestions for recovering from the fault condition.

Code	Description	Suggestions for Recovery
F1	Intra-processor communication fault.	• Reset the drive by pressing the STOP key. • Cycle power. • Consult BERGES.
F2	Internal data error.	• Reset the drive by pressing the STOP key. • Consult BERGES.
F10	Internal watchdog timer fault.	• Reset the drive by pressing the STOP key. • Cycle power. • Consult BERGES.
F11	Internal clock error.	
F12	Keypad error.	
F13	Illegal internal operation.	
F14	Internal module calibration fault.	
F15	Programming error.	• Reset parameters to factory defaults (set **801-PRGNO** to data value 1), and then re-initiate customization. • Consult BERGES.
F16	Programming error.	
F17	Programming error (custom set).	
F18	Programming error.	
F19	Module ID problem.	
F25 [1]	Output ground fault at start-up.	• Verify the insulation integrity of the connected motor and motor wiring.
F26 [1]	Output ground fault.	
F27 [1]	Output ground fault.	
F30	Bus overvoltage fault.	• Check the applied line voltage. • Verify that the load is not excessively regenerative. • Increase the deceleration time. • Reduce the regenerative torque limits (the value of parameters **603-RTLF** and **604-RTLR**).
F35 [1]	Bus overvoltage fault at start-up.	• Check the applied line voltage.
F40 [1]	Input phase loss.	• Check the applied line voltage. • Set **620-PHLOSS** to inactive.
F45 [1]	Dynamic braking overload fault.	• Verify the size of the dynamic braking circuitry/drive. • Increase the deceleration time. • Increase the process cycle time.
F50	Drive overtemperature fault.	• Verify that the ambient temperature is within the drive's specifications. • Verify that the cooling fan, if present, is functioning properly.
F51	Drive undertemperature fault.	• Verify that the ambient temperature is within the drive's specifications; increase the ambient temperature if necessary.

[1] May be automatically reset and a re-start attempted (Parameter **608-NRST** or **609-DRST**).

Code	Description	Suggestions for Recovery
F60	Phase T1 current fault.	• Reset the drive by pressing the STOP key. • Check motor and motor wiring.
F61	Phase T2 current fault.	
F62	Phase T3 current fault.	
F65 [1]	Overcurrent fault at start-up.	• Check motor and motor wiring. • Consult BERGES.
F66 [1]	Overcurrent fault.	• Check motor and motor wiring. • Verify that the value of **502-BOOST** is set properly. • Extend the acceleration ramp (increase the value of **402-ACC1** and/or **404-ACC2**).
F67 [1]	Overcurrent fault at start-up.	• Check motor and motor wiring. • Consult BERGES.
F68 [1]	Overcurrent fault at start-up.	
F69 [1]	Overcurrent fault.	• Check motor and motor wiring. • Verify that the value of **502-BOOST** is set properly. • Extend the acceleration ramp (increase the value of **402-ACC1** and/or **404-ACC2**).
F70	External fault input active.	• Check the digital input device for the external fault.
F71	Motor PTC (external) fault.	• Verify the PTC with the temperature of the motor and motor wiring. • Verify programming.
F72	Modbus communication watchdog fault.	• Check the setting of parameters **802-START** (setting 8...11) and **954-MBTO**. • Increase the value of **954-MBTO**.
F80	Input signal at A1 is out of range.	• Verify/correct the problem at A1.
F81	Calibration error for input signal A1.	• Verify the values of parameters **206-A1OFF** and **207-A1SPN** with the signal applied.
F82	Timed overload fault.	• Check for an overload on the motor. • Verify the values of parameters **607-TOL** and **610-TOLC** against the capabilities of the motor.
F90	Number of auto-restart attempts exceeded.	• Verify the causes of the most recent faults (read parameters **005-FLT5** through **009-FLT1**), and take corrective actions. • Review the values of parameters **608-NRST** and **609-DRST**, and adjust if necessary.
F91	Torque limit timeout fault.	• Verify that the connected load is not excessively regenerative. • Verify the sizing of the dynamic braking circuitry/drive. • Increase deceleration time. • Increase the process cycle time.

[1] May be automatically reset and a re-start attempted (Parameter **608-NRST** or **609-DRST**).

8 Hexadecimal to Binary Conversion

The EF1 Microdrive utilizes hexadecimal numbers to display and store the binary values of some parameters. These parameters are read and written as four-digit hexadecimal values. The hexadecimal values are then translated to binary values, with the binary values being compared to the “key” provided for each parameter to determine what status is shown or what action is commanded.

The following table shows the sixteen hexadecimal values and the corresponding binary values. The binary values are divided into four columns so you may more readily see which bits of the status or control words are affected by the binary values.

Hexadecimal Value	Binary Value			
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
A	1	0	1	0
B	1	0	1	1
C	1	1	0	0
D	1	1	0	1
E	1	1	1	0
F	1	1	1	1
	15 11 7 3	14 10 6 2	13 9 5 1	12 8 4 0
	Corresponding Bit Positions of Parameter Words			

9 Fundamentals of PI Control

9.1 Introduction

The EF1 Microdrive has a built-in PI (Proportional-Integral) Controller that makes it possible to control a process by adjusting motor speed using a reference input and a feedback input. When the drive is configured to operate with feedback from a transducer, the EF1 Microdrive essentially ceases to be a frequency controller and instead becomes a process controller.

Several EF1 parameters are specifically designed for PI control. These include:

- **801-PRGNO**
- **911-FCORR**
- **915-KP**
- **916-KI**
- **917-KIN**
- **918-PICFG**

The function performed by each of these parameters is described in the following section. Figure 14 on page 54 provides a flowchart of PI control and shows the interaction of these parameters.

9.2 Configuration of PI Control Parameters

This section discusses the parameters used for PI control and provides advice on how best to configure these parameters for your particular application.

9.2.1 Parameter 801-PRGNO

Parameter **801-PRGNO**, the parameter to set and assign special functions must be set to 80 in order to activate the PI controller. This results in a changed configuration of the control terminals or the parameters **201-MODE** (the analogue input A2 is used as the target value input instead of A1) and **204-FSEL** (only the data values 0 to 3 are permitted and A1 becomes the input for the return signal while A2 becomes the input for the frequency target value).

9.2.2 Parameter 911-FCORR

Parameter **911-FCORR** sets the frequency correction limit. The value stored in this parameter is used to limit the drive's response to a change in, or loss of, the feedback signal.

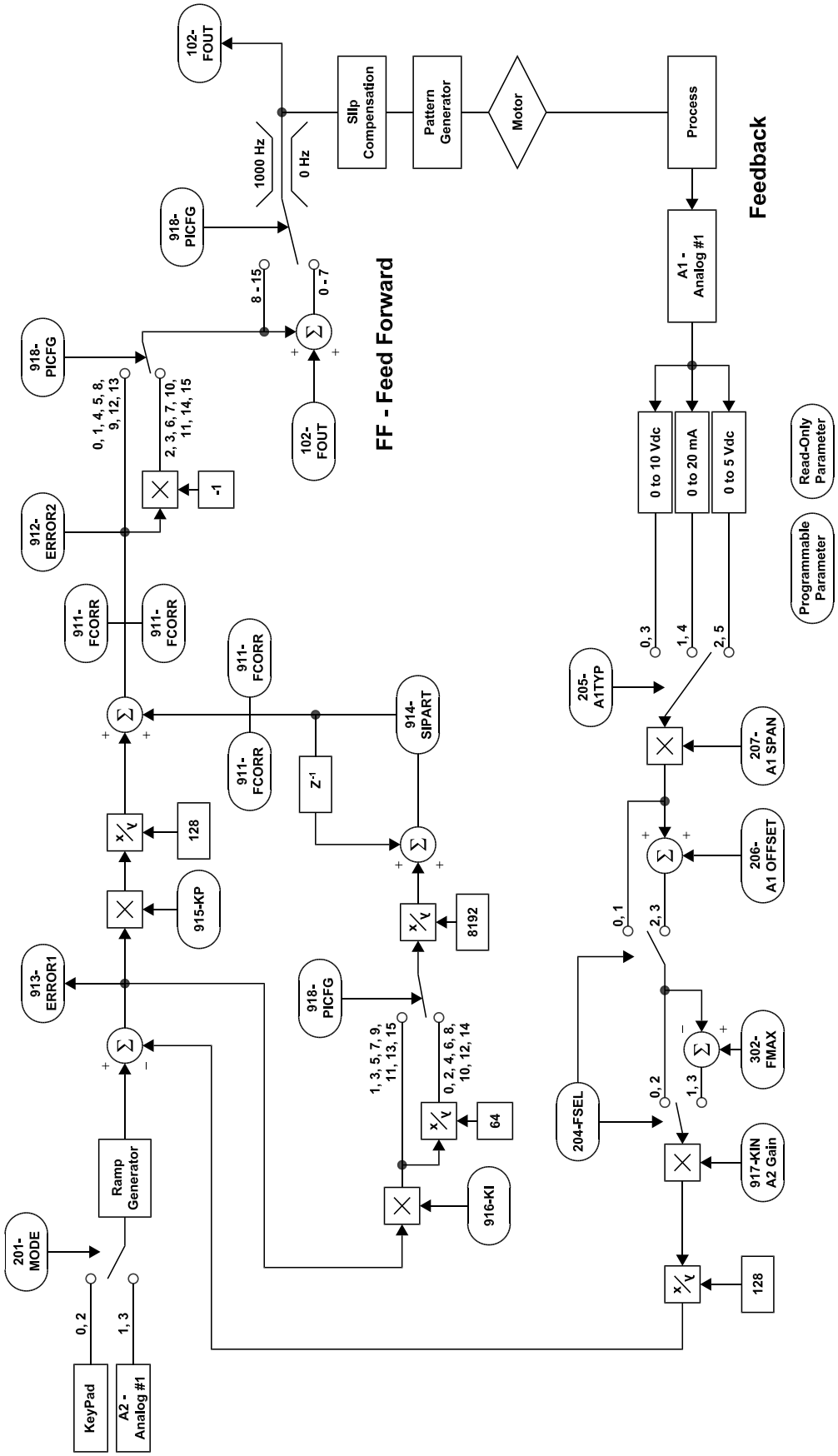


Figure 14
PI Controller Functional Diagram

9.2.3 Parameter 915-KP

Parameter **915-KP** is the proportional feedback gain for the process control loop. It determines the overall effect on the process for an incremental change in the feedback signal.

Generally, when configuring this parameter, you must observe the drive's response to an incremental change in the feedback input, and then decide if this response is sufficient.

For example, if the feedback input changes 1 V (or 1 mA), what is the drive's response? Is it enough or too much?

9.2.4 Parameter 916-KI

Parameter **916-KI** is the integral feedback gain for the process control loop. This parameter determines the short-term effects of a change in the feedback signal.

Generally, when configuring this parameter, you must observe the drive's response to an incremental change in the feedback input over a certain length of time, and then decide if this response is acceptable.

For example, if the feedback input changed 1 V (or 1 mA) for 5 seconds, what is the drive's response? Is it acceptable? Would you prefer to have the drive ignore a change over such a short time period, but still react to longer time durations (say, 8 to 10 seconds)? (If so, decreasing the integral gain by reducing the value for parameter **916-KI** would have that effect.)

9.2.5 Parameter 917-KIN

Parameter **917-KIN** is the feedback scaling factor. It is used to scale the signal supplied by the transducer – thereby optimizing the effect of the signal on the drive.

9.2.6 Parameter 918-PICFG

Parameter **918-PICFG** determines the characteristics of the process control loop. The following paragraphs discuss each of these characteristics in more detail:

1) Direct- or inverse-acting loop

In a direct-acting loop, as the process speed increases, the feedback signal will decrease and cause a corresponding decrease in the process speed as it approaches the regulation point. This type is typically employed in pump applications where the level control is the process variable.

Conversely, in an inverse-acting loop, as the process speed increases, the feedback signal increases but causes a corresponding decrease in the process speed as it approaches the regulation point. This type is typically employed in supply pump applications where the pressure is the process variable.

2) Slow or fast rate of response

Whether the rate of response is fast or slow is relative; that is, one cannot assign a specific threshold and then say the response is fast or slow based on whether the threshold is crossed. Instead, you must determine by observation whether a change in the process speed causes a change in the feedback signal quickly enough for the requirements of your application.

A slow rate of response (over 10 s, usually) is most often selected for processes with long time constraints (for example, thermal and fluid level controls). On the other hand, a fast response rate is utilized for processes with short time constraints (such as mechanical systems and pressure loops). Most industrial systems require a slow rate of response.

3) Whether feed-forward is enabled

Feed-forward is usually enabled when there is very little difference between the process speed and the feedback signal.

For example, feed-forward is useful in “speed regulation” situations, such as controlling motor speed in a closed loop. Note that feed-forward should be enabled when attempting to close a speed loop.

Feed-forward is not suited to applications such as pressure regulation systems because generally the process speed and the process variable are vastly different.

4) Whether PI control is enabled via a digital input

A digital input, when properly configured via the corresponding parameter, may be used to toggle PI control.

Generally, a digital input is used when the process will be operated as both a closed and an open loop and/or when circumstances may arise where you would want to override the process speed as determined by the process variable and reference.

REMEMBER: to complete the implementation, you must configure a digital input separately to invoke PI control.

9.3 Tuning the PI Control Loop

Once the parameters are initially configured (parameter **918-PICFG**), you should tune them so the process control loop operates as optimally as possible. To make tuning easier, the following recommendations should be observed:

- If your application does not require enabling by digital input, for the duration of tuning you should select a value for parameter **918-PICFG** which does allow a digital input to enable PI control. Once tuning is finished, you can restore the parameter to its original value.
- Install a switch to select closed loop and open loop performance.
- Connect a calibration signal to the drive to simulate the effects of the transducer’s signal. While this is not absolutely required, it can be very helpful.

Once the preparations for tuning are complete, enable PI control via the digital input and set the switch to open loop. Then operate the drive, utilizing any necessary instrumentation (for example, pressure gauges, meters, etc.) to characterize the range of the signal supplied from the transducer (for example, at 3 PSI, the transducer provides 1 V). This will aid in better understanding the operation of the system and make calibration easier.

Select a mid-range operating point for the system and inject a signal close to that which the transducer would provide at that point. Vary the signal by the value determined by the set-up technician and determine whether the proportional response of the system is appropriate. If the questions posed in the previous section are answered correctly and your initial assumptions prove correct, a combination of input scaling and proportional gain should make the performance match the system.

Next, examine the transient or short-term effects that are common on all real-world systems. Use the calibrator to change the feedback signal by some value for a measured interval, with the value and duration approximating the real system.

For example, say 1 V for 5 seconds was selected. By monitoring parameter **912-ERROR2**, the effect of the feedback signal may be observed. The value of this parameter should increase and then settle back to zero, or perhaps go below zero (negative). The value of the parameter may go positive and negative a number of times as a response to repeated 5 second transients. Tune parameter **916-KI** to optimize this effect to suit the circumstances.

Finally, put the transducer into the circuit and review the results. The results will likely show that the value of parameter **916-KI** needs to be modified to complete the implementation. Minor adjustment of the other PI control parameters may also be necessary.

Once the process control loop is optimally functioning, if you changed the value of parameter **918-PICFG** for tuning, restore it to its original value.

If you need further assistance or advice, please contact BERGES.

10 Summary of EF1 Parameters

Parameter	Parameter Name	Level	Range	Default	Page
002-RVLVL	Software Revision	L2		Read-Only	25
003-IRAT	Drive Rated Current	L2	varies	Read-Only	26
005-FLT5	Most-recent Fault	L1		Read-Only	26
006-FLT4	Second-oldest Fault	L2		Read-Only	26
007-FLT3	Third-oldest Fault	L2		Read-Only	26
008-FLT2	Fourth-oldest Fault	L2		Read-Only	26
009-FLT1	Oldest Fault	L2		Read-Only	26
102-FOUT	Motor Output Frequency	L1	0...1000 Hz	Read-Only	26
103-VOUT	Motor Output Voltage	L1	0...100%	Read-Only	26
104-IOUT	Motor Output Current	L1	0...60 A	Read-Only	26
105-LOAD	Drive Load	L1	0...200%	Read-Only	26
107-TEMP	Drive Temperature	L1	0...110 °C	Read-Only	27
110-WARN	Warning Code	L1	0...6	Read-Only	27
201-MODE	Input Mode	L1	0...11	0	27
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210-TLSEL	Torque Limit Source Selection	L2	0...3	0	29
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304-F3	Preset Frequency F3	L2	0...1000 Hz	20 Hz	30
305-F4	Preset Frequency F4	L2	0...1000 Hz	40 Hz	30
306-F5	Preset Frequency F5	L2	0...1000 Hz	50 Hz	30
307-F6	Preset Frequency F6	L2	0...1000 Hz	0 Hz	30
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510-VHZ1F	V/Hz Frequency, Point 1	L2	0...1000 Hz	0 Hz	37
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512-VHZ2F	V/Hz Frequency, Point 2	L2	0...1000 Hz	0 Hz	37
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TB Wood's

BERGES

Berges electronic GmbH

Industriestraße 13
D–51709 Marienheide-Rodt
Postfach 1140 • D–51703 Marienheide
Tel. +49 (0)2264 17-0
Fax +49 (0)2264 17126
http://www.berges.de
info@berges.de

Berges electronic s.r.l.

Zona industriale, 11
I–39025 Naturno Italy
Tel. +39 (0)473 671911
Fax +39 (0)473 671909
http://www.berges.it
info@berges.it

Uff. vendite Milano

Via Monteverdi, 16
I–20090 Trezzano sul Naviglio (MI)
Tel. +39 (0)2 48464206
Fax +39 (0)2 48499911

TB Wood's Incorporated

440 North Fifth Avenue
Chambersburg, Pennsylvania 17201-1778
Telephone: 888-TBWOODS or 717-264-7161
Fax: 717-264-6420
http://www.tbwoods.com
info@tbwoods.com